

The AMSAT[®] Journal

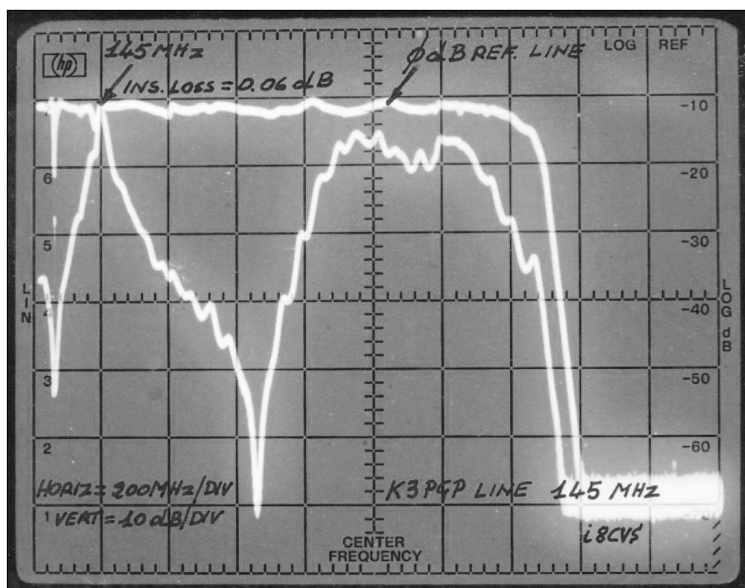


Editor-in-Chief:
Ed Long, WA4SWJ

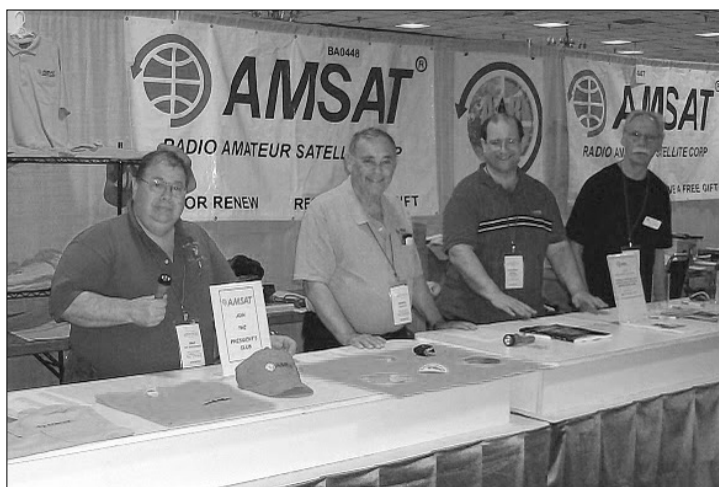
Assistant Editors:
Bill Hook, W3QBC
JoAnne Maenpaa, K9JKM

Volume 33, Number 3

May/June 2010



Protection for your preamp



Waiting for the Dayton crowd

in this issue

- AMSAT Announcements2
- Apogee View3
by Barry Baines • WD4ASW
- Filter and Receiver Front End4
Protection Device for 144 MHz EME
by Domenico Marini • I8CVS
- Pocket Cube Simulator9
by Mark Spencer • WA8SME
- AMSAT at Dayton 2010 11
by Alan Biddle • WA4SCA
- Medium Earth Orbit - An15
Affordable Alternative to HEO?
by David Bowman • G0MRF
- AMSAT Telemetry24
- HOPE-OSCAR 68: A New26
Hope in Space - XW-1
by Mike Rupprecht • DK3WN

Periodicals
POSTAGE PAID
At Silver Spring, MD
and at additional
mailing offices

AMSAT-NA
850 Silgo Avenue, Suite 600
Silver Spring, MD 20910-4730

How You Can Help Build New and Exciting Satellites

Donate to the President's Club

Gold, Silver, Bronze and Core levels are available to match your ability to participate.

Cash Gifts

Visa, or MasterCard or checks are accepted. And, you can specify how your contribution is to be used.

Gift of Life Insurance

US taxpayers may be able to receive a significant income tax deduction by making The Radio Amateur Satellite Corporation the owner and beneficiary of life insurance policies.

Gift of Stocks or other Securities

US taxpayers should be able to avoid capital gains taxes on appreciated securities and receive a deduction for their fair market value.

Bequest

A codicil in your will, naming The Radio Amateur Satellite Corporation as a beneficiary will help insure the continuance of the Amateur Radio Satellite program.

Call the AMSAT-NA office at 301-589-6062 for questions on any or all of these ways you can help build new and exciting satellites.

Support AMSAT-NA

AMSAT Announcements

2010 AMSAT Space Symposium and Annual Meeting - Call for Papers

This is a reminder of the call for papers for the 2010 AMSAT Space Symposium and Annual Meeting to be held October 8 - 10 at the Chicago/Elk Grove Holiday Inn which is near O'Hare Airport. The Symposium Committee invites proposals for:

- + Papers for publication in the Proceedings
- + Symposium Presentations
- + Poster Presentations
- + Equipment and Operating Demonstrations

These can be on any topic of interest to the amateur satellite community. We request a tentative title of your presentation as soon as possible, with final copy submitted by September 1, 2010 for inclusion in the printed proceedings.

Abstracts and papers should be sent to JoAnne Maenpaa, K9JKM, at k9jkm@comcast.net. 🌐

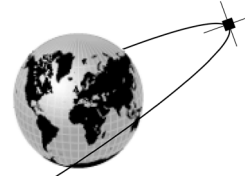
AMSAT's Mission

AMSAT is a non-profit volunteer organization which designs, builds and operates experimental satellites and promotes space education. We work in partnership with government, industry, educational institutions and fellow Amateur Radio societies. We encourage technical and scientific innovation, and promote the training and development of skilled satellite and ground system designers and operators.

AMSAT's Vision

Our Vision is to deploy satellite systems with the goal of providing wide-area and continuous coverage. AMSAT will continue active participation in human space missions and support a stream of LEO satellites developed in cooperation with the educational community and other amateur satellite groups.





Radio Amateur Satellite Corporation (AMSAT-NA)
850 Sligo Ave., Silver Spring, MD 20910-4703
Telephone: 301-589-6062 – Toll Free: 888-322-6728
Facsimile: 301-608-3410
AMSAT-NA Club Callsign: W3ZM
AMSAT-NA Web site: <http://www.amsat.org>

The AMSAT Journal Staff

Editor-in-Chief: Ed Long, WA4SWJ, wa4swj@amsat.org
Assistant Editor: Bill Hook, W3QBC, w3qbc@amsat.org
Assistant Editor: JoAnne Maenpaa, K9JKM, k9jkm@amsat.org
Circulation: Martha Saragovitz, martha@amsat.org

AMSAT-NA Board of Directors

Barry Baines, WD4ASW, wd4asw@amsat.org
Alan Biddle, WA4SCA, wa4sca@amsat.org
Tom Clark, K3IO, k3io@amsat.org
Drew Glasbrenner, KO4MA, ko4ma@amsat.org
Lou McFadin, W5DID, w5did@amsat.org
Bill Ress, K6GHZ, k6ghz@amsat.org
Gould Smith, WA4SXM, wa4sxm@amsat.org
Tony Monteiro, AA2TX, aa2tx@amsat.org - Alternate

AMSAT-NA Senior Officers

President: Barry Baines, WD4ASW
Executive Vice-President: Open
Treasurer: Keith Baker, KB1SF/VA3KSF
Secretary: Alan Biddle, WA4SCA
Manager: Martha Saragovitz
Vice-President, Engineering: Tony Monteiro, AA2TX
Vice-President, Operations: Drew Glasbrenner, KO4MA
Vice-President User Services: Gould Smith, WA4SXM
Vice-President Human Spaceflight: Open
Vice President, Marketing: Open

Honorary Positions

Immediate Past President: Rick Hambly, W2GPS
President Emeritus: Tom Clark, K3IO
Founding President: Perry Klein, W3PK

Editorial Office: Ed Long, WA4SWJ, 4420 SE 106TH ST, Belleview, FL, 34420-6835. Please e-mail Journal submissions to: journal@amsat.org.
Editor's telephone: 262-374-1349 (cell). **Advertising Office:** AMSAT-NA Headquarters, 850 Sligo Avenue, Suite 600, Silver Spring, MD 20910-4703, Telephone: 301-589-6062.

The AMSAT Journal (ISSN: 1407-3076) is published bi-monthly (Jan/Feb, Mar/Apr, May/Jun, Jul/Aug, Sep/Oct, Nov/Dec) by AMSAT-NA, 850 Sligo Avenue, Suite 600, Silver Spring, MD 20910-4703. Telephone: 301-589-6062, fax: 301-608-3410. Periodicals postage paid at Silver Spring, MD and additional mailing offices.

Postmaster: Send address changes to *The AMSAT Journal*, 850 Sligo Avenue, Suite 600, Silver Spring, MD 20910-4703.

Opinions expressed in *The AMSAT Journal* are those of the article authors and are not necessarily those of AMSAT-NA. Copyright © 2010 by AMSAT-NA. The Radio Amateur Satellite Corporation. AMSAT is a registered trademark. Reproduction of material from *The AMSAT Journal* by mechanical, electronic, photocopy or other means is prohibited unless written permission is obtained from the author.

The AMSAT Journal staff is always interested in article submissions. Whenever possible, submissions should be sent via e-mail to journal@amsat.org using plain text or word processor files; photos or figures in TIF, GIF or JPEG formats. Kindly do not embed graphics or photos in your manuscript - we prefer receiving those as separate files. AMSAT-NA reserves the right to select material for *The AMSAT Journal* based on suitability of content and space considerations. The editors of this publication are volunteers giving freely of their talents, time and efforts to produce *The AMSAT Journal*.

AMSAT enjoyed a successful Dayton Hamvention. A 3-day marathon, Hamvention provides a unique opportunity for AMSAT to connect not only with the 20,000+ attendees, but also with other organizations and AMSAT members in attendance. This year's Hamvention appears to have been more successful for vendors, including AMSAT, as we exceeded revenues from the 2009 Hamvention.

There is a separate article in this issue on AMSAT's Hamvention activities, so there isn't much point in repeating here what is described elsewhere. I would like to point out a few key observations:

1. ARISSat-1 development continues along to meet a July 1, 2010 delivery date. The ARISSat-1 prototype was on display and operating during Hamvention. The display allowed, for example, various leaders from the ARRL to view the satellite and better understand the educational outreach opportunities to be provided by this satellite.
2. SUNY-Binghamton provided a display of their work this academic year on pseudocapacitors and development of deployable panels on a 3U cubesat. Dr. Roger Westgate, WC2R, is the faculty advisor for this project and he gave a presentation at the AMSAT Forum on the results of their work.
3. The AMSAT-TAPR dinner was well attended and everyone enjoyed the presentation given by Dr. Robert McGwier, N4HY, on the technical accomplishments of Amateur Radio over the past 25 years and their impact on commercial telecommunications.
4. The AMSAT Forum was packed. Along with Dr. Westgate's presentation, there were talks on ARISSat-1, the status of current satellites in operation, future space projects, and a status report on AMSAT. We expect to have video of the AMSAT presentations available shortly from the AMSAT Web site.
5. The satellite demos, led by Keith Pugh, W5IU, and Drew Glasbrenner, KO4MA, were an outstanding success with scores of people participating.

Many thanks to the volunteers who helped to make Dayton such a success for AMSAT by assisting with booth setup and takedown, manning the booth during the 22 hours that the Hamvention commercial area was

open. In particular, I want to recognize Gould Smith, WA4SXM, for his dynamic leadership at Dayton and the untold hours that he spent organizing everything. In addition, Gould updated and released the latest edition of *Getting Started with Amateur Satellites*, which is a best seller for AMSAT. On top of everything else, Gould has served with distinction as the Project Manager for ARISSat-1, and he ensured that the prototype was available for viewing and operation during Hamvention.

Hamvention was also an opportunity to encourage donations to AMSAT's satellite projects. The Dayton Amateur Radio Association (DARA) has announced a matching gift program where AMSAT has until September 1, 2010 to generate up to \$5,000.00 in donations that they will match one-for-one. At Hamvention, about \$1,800.00 was donated over the three day event with individuals placing their donations in the cookie jar at the booth. Those donations, coupled with donations received prior to Hamvention, means that we're about 60% of goal. [See update on page 24 - Ed.] AMSAT will have a booth at Hamcon in Plano, TX June 12-13 where hopefully more donations will be received and of course contributions may be made through the AMSAT Web store.

We were also fortunate to meet with a delegation from the newest AMSAT international organization, AMSAT-Turkey. The Interim President of AMSAT-TR, A. Tahir Dengiz, TA2T, attended the Thursday evening bash at Tickets Pub and Eatery in Fairborn. On Saturday, he was joined by other AMSAT-TR officers, including Levent Sasmazel, WW2L, and Mehmet Ozcan, NA5B, (Turkish nationals working in the US) as well as Dr. Alim Rustem Alan, Professor of Aerospace Engineering at Istanbul Technical University as they attended the AMSAT Forum and we took a moment to recognize their presence. That evening, they met with AMSAT officers at the local Quaker State eatery. Having dinner together provided an opportunity to exchange suggestions on establishing lines

continued on page 22 ...



Filter and Receiver Front End Protection Device for 144 MHz EME

by Domenico Marini, I8CVS, domenico.i8cvs@tin.it

Introduction

When using high power for EME, even with high attenuation between ports of the antenna relay, it is very easy to destroy a preamplifier GaAsFET device if additional precautions are not taken. One cure for the problem is to use a Filter/Protection Device between the RX port of the coax relay and the input of preamplifier. One such device was originally designed early in 1977 for 432 MHz EME by John, K3PGP, and is described in this Web site: <http://www.k3pgp.org/432filter.htm>

How the Filter/Protection Device is Made and Works

After building many K3PGP Filter/Protection Devices for 432 MHz, I decided to scale one for 144 MHz EME. It works very well with QRO amplifiers. The Filter/Protection Device consists of a low Q half wave transmission line with two diodes at the peak voltage point and has an insertion loss of less than 0.1 dB at 144 MHz. The 144 MHz unit is shown in Photo 8. It provides the bonus of additional selectivity with the -3dB points at approximately 137 and 153 MHz to clean up the garbage outside its 16 MHz bandwidth at most locations.

The diodes are connected back to back in anti-parallel at the center of the half wave transmission line, i.e., at the peak voltage point. If RF power accidentally enters the TX end due to improper coax relay switching, the diodes start to conduct and the center of the filter becomes a short circuit.

In this condition the half wave transmission line looks like two 1/4 wave transmission lines back to back with the central common end shorted out by the diodes. So both ends of the lines, where the connectors are fitted, rise from 50 ohms to a very high impedance (infinity in theory) inside the passband. In fact, with a test pulse of 1000 watts applied to the input of the Filter/Protection Device, less than 80 mW was measured at the output. Thus, the TX to RX attenuation at high power level becomes:

$$10 \log_{10} (1000/0.08) = 41 \text{ dB}$$

Photo 7 shows the frequency response as a band pass filter from 10 to 1300 MHz with a minimum attenuation of 0.1 dB at 144 MHz.

Photo 9 shows the output of the protection device when the input is connected to a 144 MHz RF generator. When the level of the RF generator applied to the input is increased from -60 dBm to -10 dBm the output changes linearly because the diodes are not conducting. However, as soon as the RF generator is increased from 0 dBm to +20 dBm the output is compressed and changes only by 10 dB because the diodes start to conduct and the input power is reflected back to the RF generator.

Since the log reference line of the spectrum analyzer (Photo 9) is 0 dBm, the attenuation of the protection device is already 20 dB with +20 dBm input power. Increasing the input power to +30 dBW (1000 watts) with

a short pulse (not shown in the diagram) an attenuation of more than 40 dB was measured.

Photo 10 shows that the insertion loss is less than 0.1 dB at 144 MHz and the bandwidth at -3 dB points is about 16 MHz (2 dB/vertical division and 20 MHz horizontal division)

The Filter/Protection Device must be connected between the RX port of the coax relay and the preamplifier input while a separate coax line must be used between the preamplifier output and the 2 m down converter or receiver input as in Figure 2 (a).

If the antenna coax relay's attenuation, i.e., a cross talk, is say 60 dB at 144 MHz, then the total TX/RX attenuation becomes $60 + 41 = 101 \text{ dB}$, which is more than sufficient for preamplifier safety purposes using a QRO EME 2 meter power amplifier.

Construction

Following the drawing in Figure 1 and the straightforward Photos 1 through 6, duplication of the filter construction is very easy.

Obtain some brass square tubing 1" x 1" (25.4 x 25.4 mm) and 18" long (457.2 mm). Prepare two 1" x 1" square plates from brass sheet and drill a 2 mm hole in the center of each piece. One side of the square tubing is 1" x 18" long and it must be drilled to receive 3 longitudinal holes. A center hole diameter of 15/64" (6 mm) is drilled to receive a high

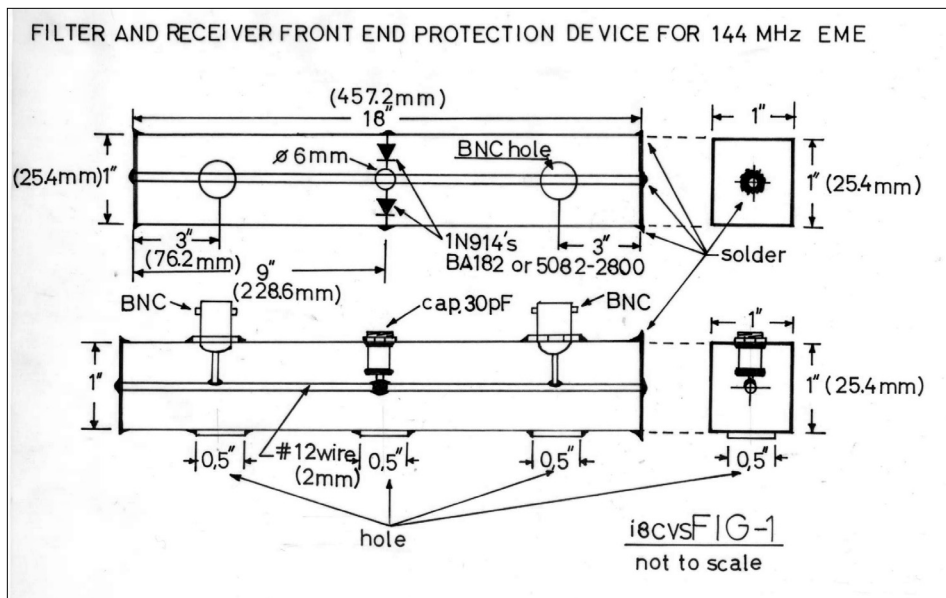


Figure 1: Construction details.

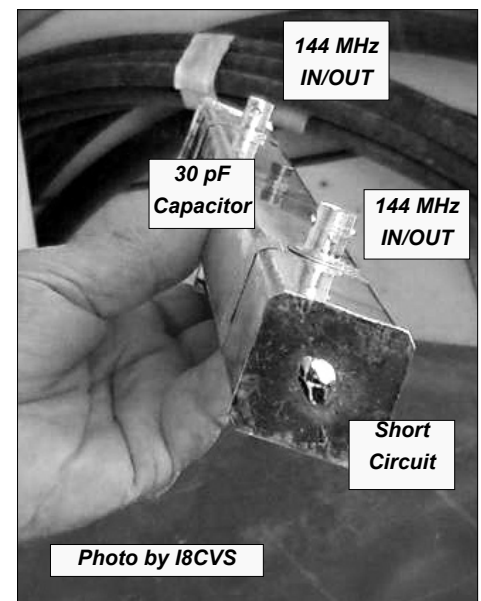


Photo 1: End view of the device.

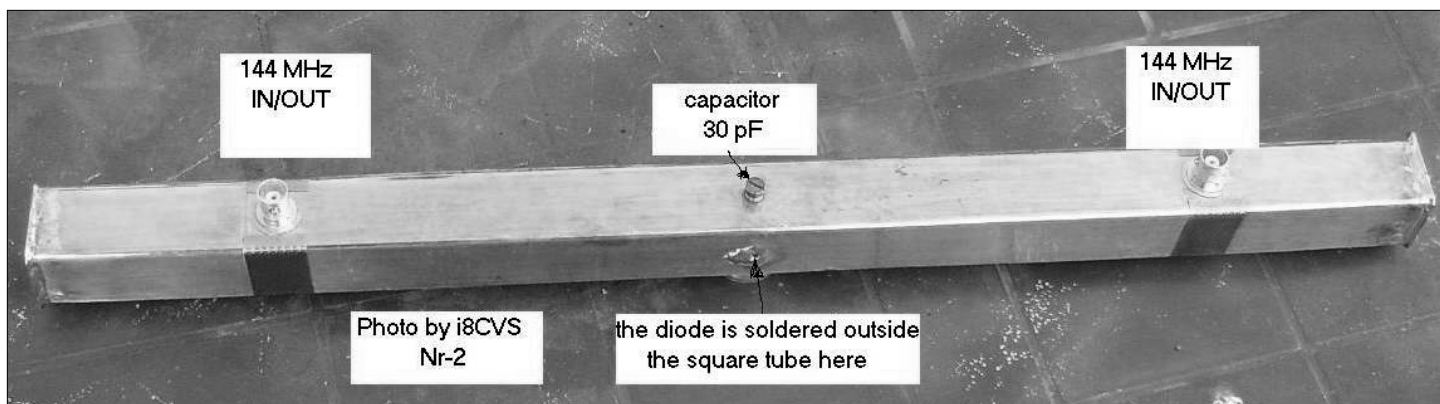


Photo 2: Front view.

Q variable capacitor. The variable capacitor is an Airtronic type 5602, with a capacitance range of from 1 to 30 pF and a $Q > 5000$ at 100 MHz. Equivalent capacitors from Johanson will also work.

Both connector holes must be drilled 3" (76.2 mm) from each end of the square tube. The diameter of the hole depends if a female BNC or a female N connector is used.

After the mechanical parts are cut and drilled, it is recommended that they be silver plated for better performance, particularly in the inner surface of the square tube.

Instead of using four screws to fasten the flange of connectors, it is better to directly tin solder the flange of the BNC or N connector over the outer surface of the square tube. When the connectors are mounted slip the 30 pF air trimmer inside the square tube and tighten the nut outside the center hole 15/64" (6 mm).

Obtain two diodes (1N914's or BA-182 or even better, diodes of the HP 5082-2800 family) and solder the anode of one diode and the cathode of the other diode both to

the 30 pF capacitor stud.

It is very difficult to solder the other end of the diodes to ground inside the long tube. So it is necessary to drill two small holes in the wall of the square tube and solder the terminals of the diodes (anode and cathode) to ground symmetrically to the outside of the square tube.

Now obtain a #12 AWG (2 mm) silver plated copper wire at least 20" (51 cm) long. Slip the copper wire into the tube and solder it over the capacitor stud and over both central pins of the input and output connectors.

Again, working inside a very long square tube is difficult. To solder the 2 mm copper wire to the stud of the 30 pF capacitor as well as to both central pins of the BNC or N connectors requires that three additional holes of 0.5" in diameter be drilled on the opposite side of the square tube just behind the capacitor and behind both connectors.

To close the ends of the square tube use two square plates of brass 1" x 1" (25.4 mm x 25.4 mm) and solder them along the four sides of the square tube.

Now carefully slip the copper wire into the central hole of the end 1" x 1" square plates and solder the 2 mm copper wire to ground outside the end plates of the square tube. Then solder the 2 mm copper wire inside the tube to the capacitor stud and to both connector pins. Once completed, close the three unused 0.5" diameter access holes by soldering three small thin copper or brass square plates over the holes.

Both connectors can be used for IN and OUT and they can be electrically interchanged. Since the connectors are symmetrically soldered to the center conductor with respect to the ground the impedance of the load connected to one port is seen as unchanged at the other port at resonance.

Testing and Tuning

To tune the filter, place it between the antenna and the preamplifier and adjust the capacitor for maximum output at 144 MHz using a weak local steady carrier. If a 144 MHz signal generator is used to tune the filter do not apply a power level greater than approximately - 20 dBm to prevent forward biasing the diodes into conduction. The

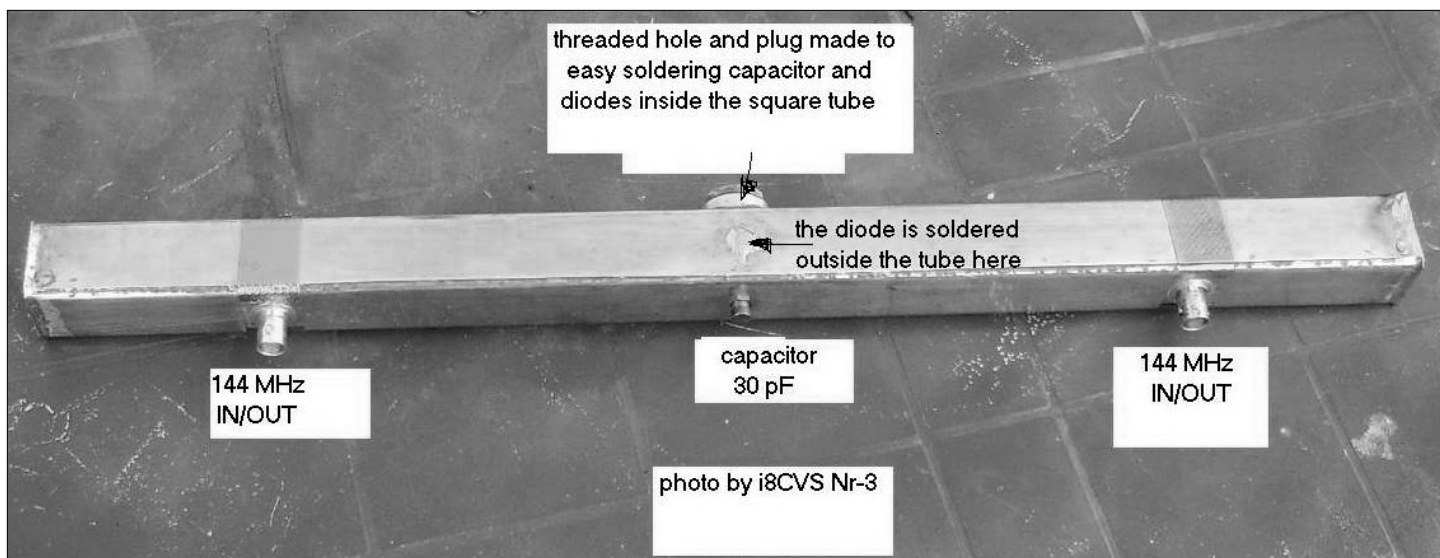


Photo 3: Side view.

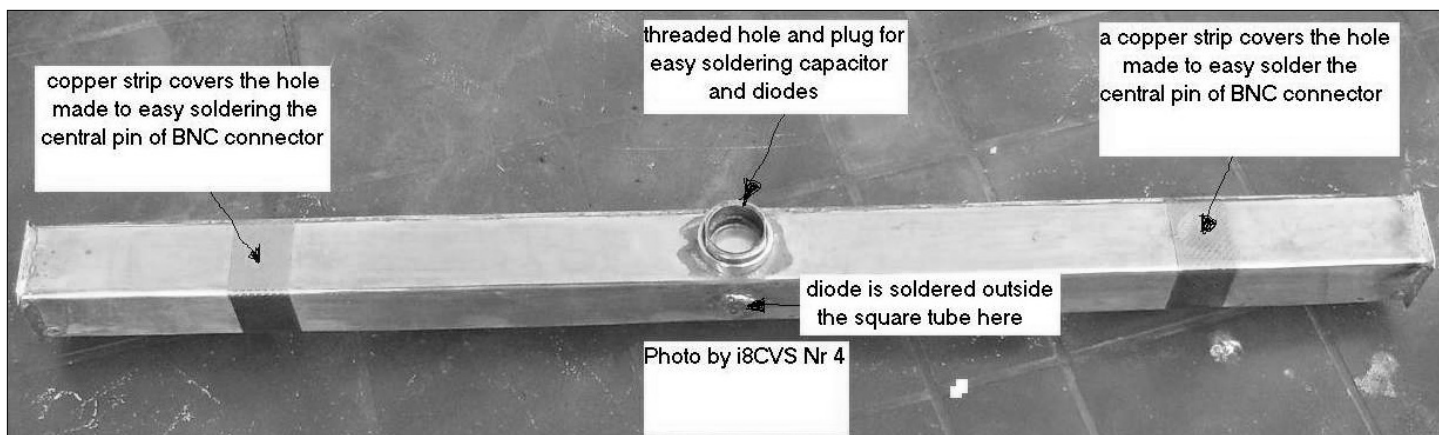


Photo 4: Back view.

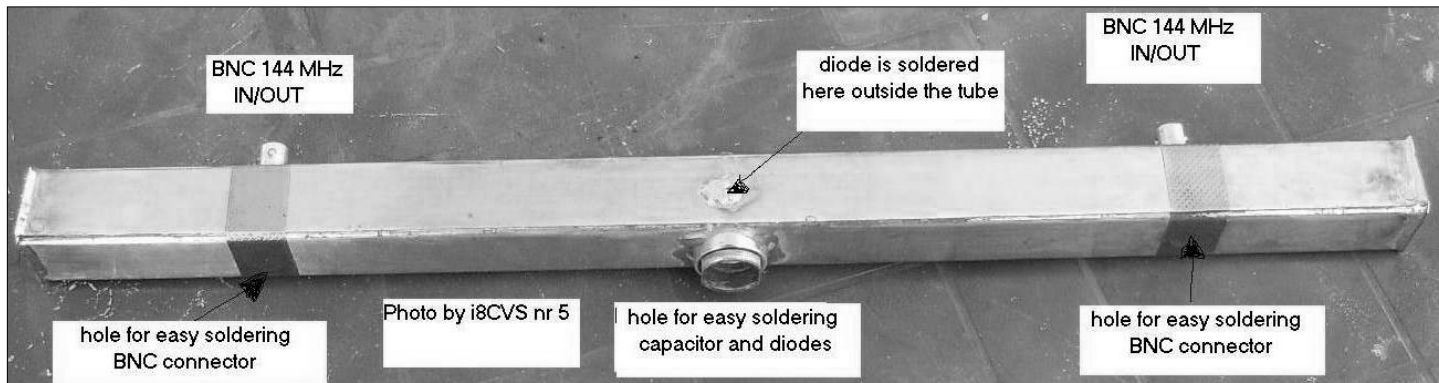


Photo 5: Opposite side view.

resonance at 144 MHz is not too sharp and is reached with the 30 pF trimmer capacitor about mid way between 15 pF to 20 pF.

If an Automatic Noise Figure Meter is available, connect the noise head to one port of the filter and the preamplifier to the other port and adjust the capacitor for the lowest noise figure at 144 MHz. Since the insertion loss of the filter is less than 0.1 dB depending on the quality of used connectors and Q of capacitor than the difference of the overall NF of the system with and without filter is very small or not considerable.

Finally connect the Filter/Protection Device to the output of a 144 MHz power amplifier using a short piece of 50 ohm coax cable. Run the amplifier at full power and the diodes will start to conduct. When they begin to conduct the center point of the filter becomes a short circuit. However, the end of the Filter/Protection Device connected to the power amplifier reflects a very high impedance so that the VSWR into the coax cable is at a maximum. This is like having the input connector of the Filter/Protection Device as an open circuit. Leaving an amplifier in this condition for long could result in heating the coax cable at a point of melting the insulating material and damaging it or the power amplifier, so don't do this for very long. However,

this test demonstrates the efficiency of the Filter/Protection Device because the power reaching the preamplifier output will be only a few mW and the GaAsFET preamplifier will be safe, alive and well.

The only operating problem I have seen a loss of received signals when a very close by QRO transmitter on the same 2 m band comes on the air and causes the diodes to conduct. But this is precisely what this device is supposed to do. Although it was designed for weak signal 144 MHz work it also worked very well for OSCAR satellite work where I am transmitting on 435 and listening on 145 or transmitting on 145 and listening on 435 where I used an identical filter scaled to 435 Mhz. I have NEVER lost a 2 m or 70 cm receiver front end when using this device.

Using the Filter/Protection Device as a TR Switch

The transmitter is connected to the antenna using a 144 MHz circulator. As shown in Figure 2 (b). Port number 1 of circulator is connected to the transmitter and port number 2 to the antenna. Port number 3 of the circulator is connected to the Filter/Protection Device which then feeds the 144 MHz preamplifier. There are no moving parts nor is bias required to go from transmit to receive with the positive result of no delay

when going from receive to transmit and back. This also makes the system failsafe as there are no bias voltages that must be present for the system to switch properly.

A similar arrangement can be used if no circulator is available. A odd number of electrical 1/4 wave pieces of coax cable must be connected from the transmitter output to the antenna and another odd number of electrical 1/4 wave pieces of coax cable must be connected from the antenna to the Filter/Protection Device, which then feeds the preamp. When the transmitter is off the odd number of 1/4 wave coax line lengths to the transmitter output keeps the transmitter from shorting out the received signal. When the transmitter is on, the diodes in the protection device will conduct, but the odd number of 1/4 wave line lengths between the antenna and the Filter/Protection Device keeps the filter from shorting out the transmitter. This is a very simple, low loss technique and again inserts NO DELAY or sequencing requirements when switching between receive and transmit. A connection diagram is shown in Figure 2 (c).

The only requirement when using this system is that the transmitter must be completely cut off during receive otherwise wide band noise will get into the receiver masking the desired signals.

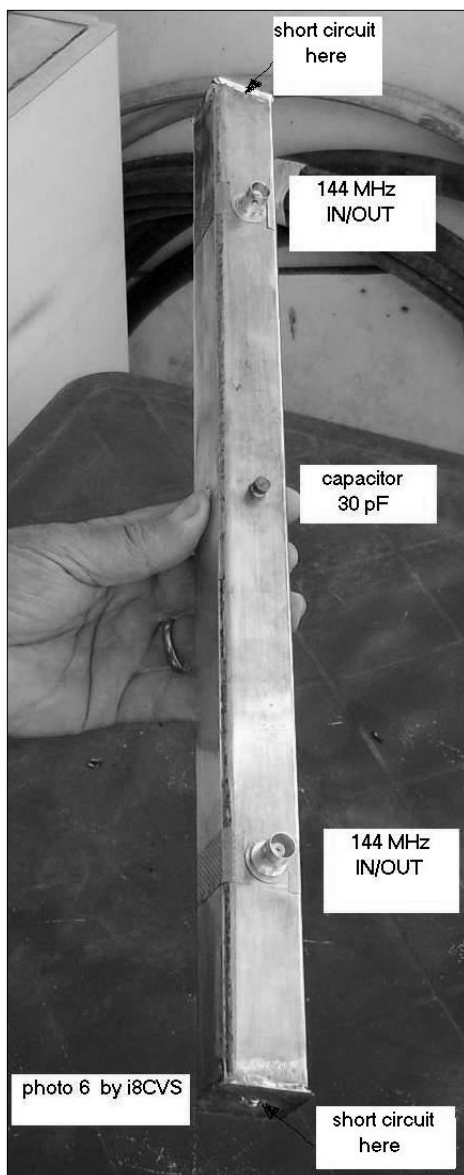


Photo 6: Overall view.

The drawing of this filter and receiver front end protection device as originally designed by John, K3PGP, for 432 MHz was published by Al, K2UYH, in the April 1977 issue of 432 EME NEWS. I have redrawn it from the original sketch at 432 MHz and I have scaled the size for use on the 144-146 MHz band along with more details and RF measurements for a better understanding of the design and how to use it.

References

- [1] <http://www.k3pgp.org/432filter.htm>
- [2] *Reflection Transmission Lines and Antennas* by M. Walter Maxwell, W2DU, ARRL, Order No 2995, ISBN 0-87259-299-5.
- [3] *The ARRL Antenna Book*, 15th Edition, Published by the American Radio Relay League. 

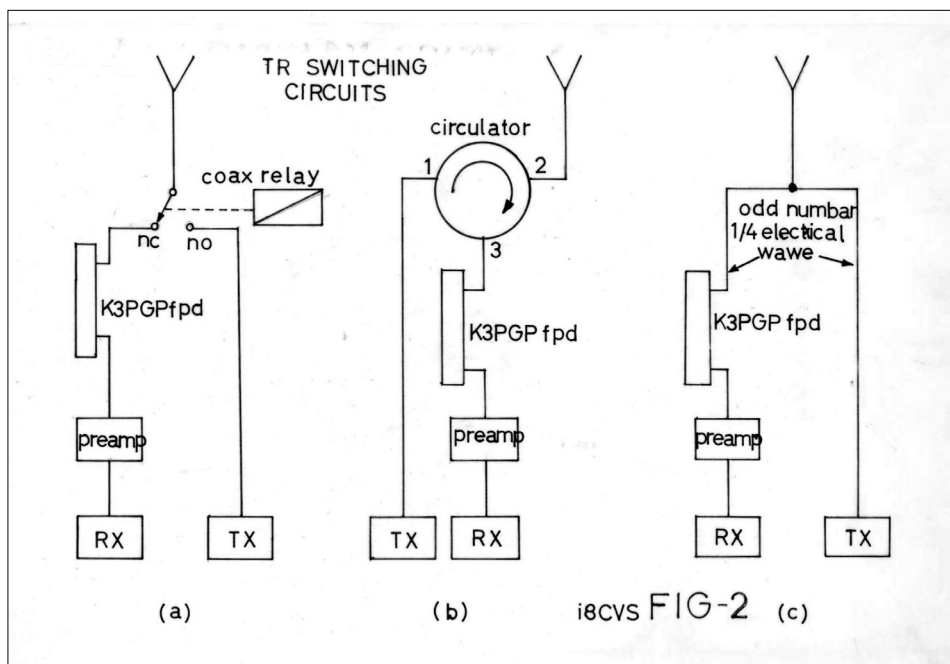


Figure 2: Application diagrams.

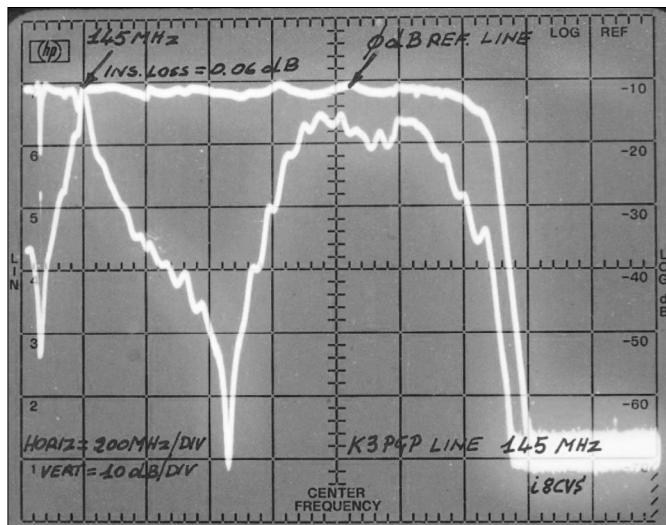


Photo 7: Bandpass filter response from 10 - 1300 MHz.

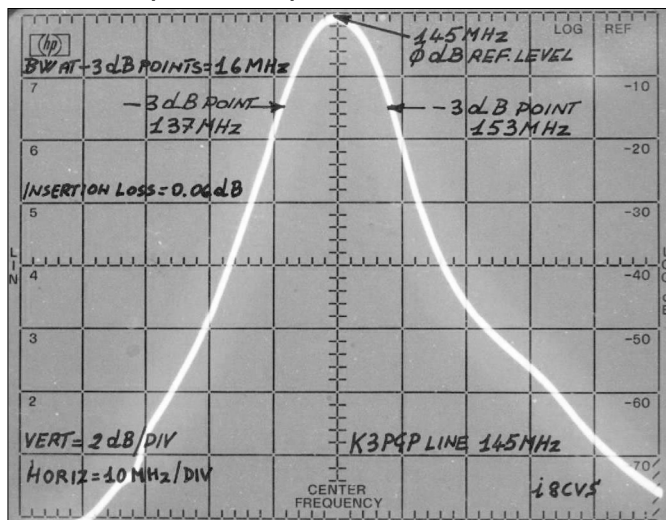


Photo 8: Frequency response -3 dB points.

Photos continue on the next page ...



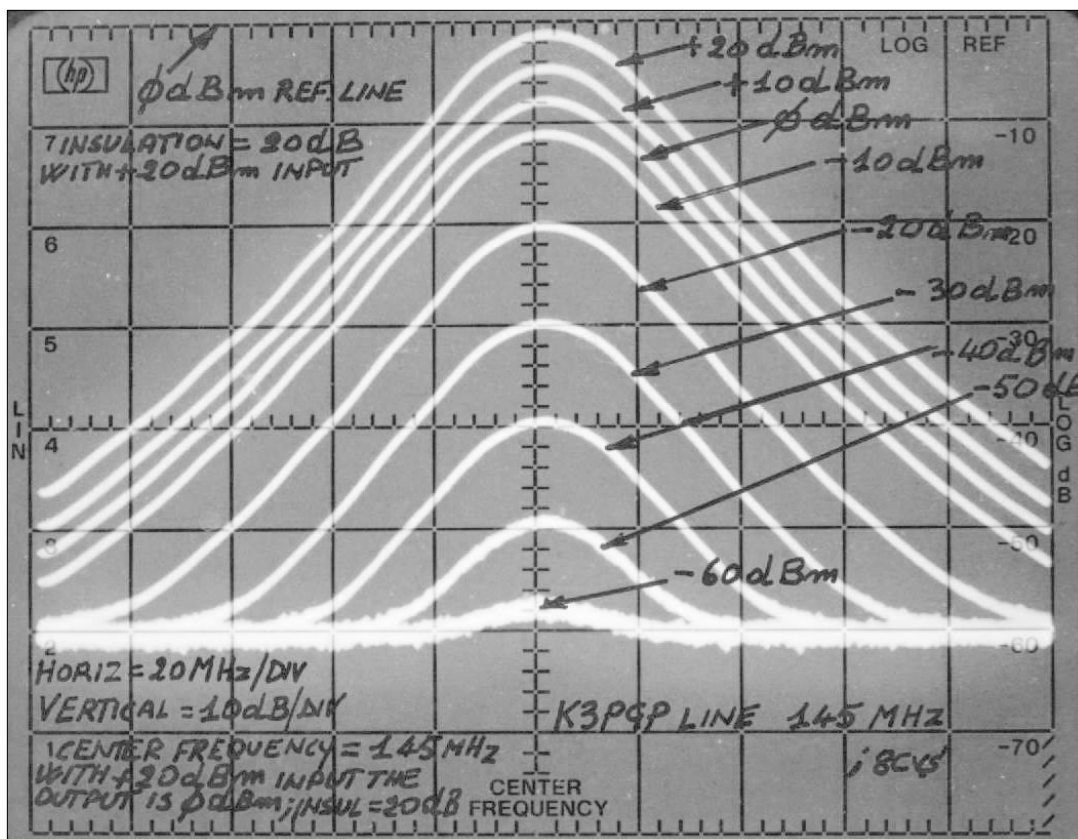


Photo 9: Output of the device showing compression once the diodes are in conduction.

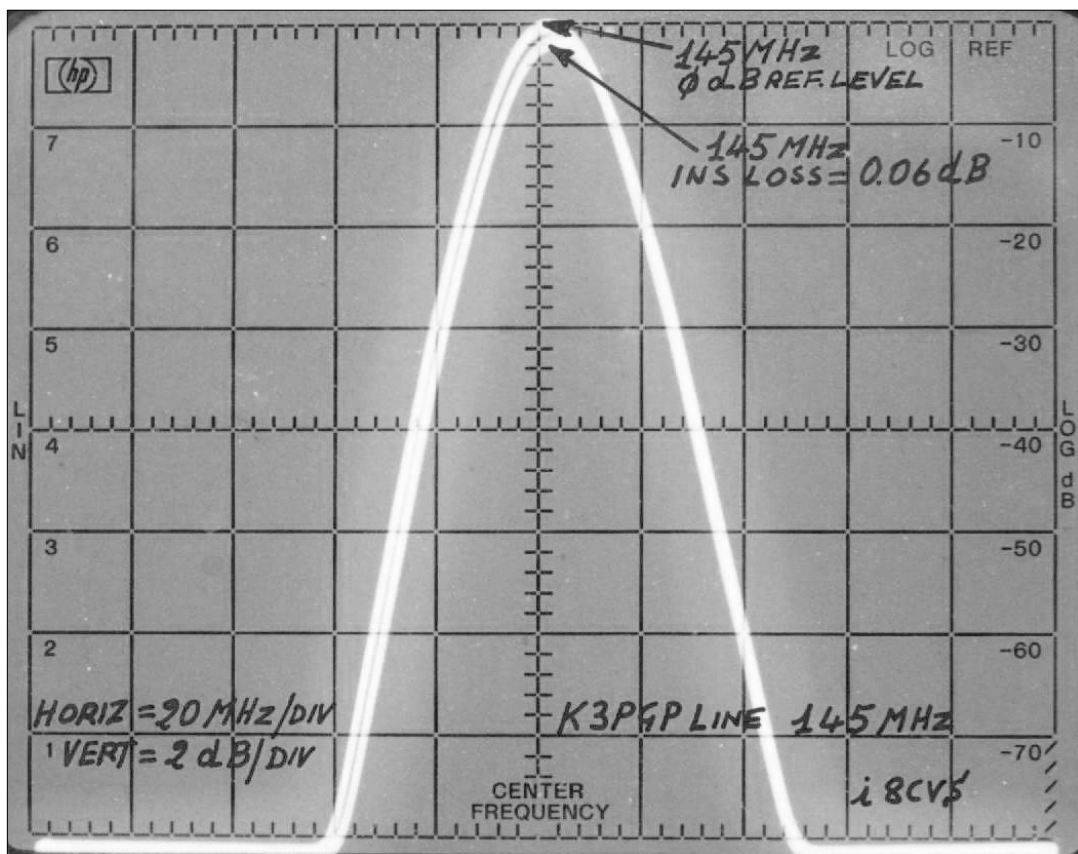


Photo 10: Insertion loss.

Pocket Cube Simulator

by: Mark Spencer, WA8SME, mspencer@arrrl.org
ARRL Education and Technology Program Coordinator

You know, sometimes you have to do stuff just for the fun of it. I recently attended the CubeSat conference at CalPoly and heard a presentation from Bob Twiggs [1] of Morehead State University (he is the father of the CubeSat concept). One portion of Bob's talk was on another innovative idea labeled the Pocket Cube. Well this presentation got my mind racing.

I had developed a CubeSat simulator (introduced in *The AMSAT Journal* previously) for use during the ARRL Teachers Institutes and as an affordable educational resource for introducing students to the fundamentals of satellite operations. This simulator is proving to be very attractive for the teacher audience as it gains exposure during each Teachers Institute and Hamvention venue where it is presented. The universal 'WOW' factor is consistently, "are the satellites really that small?" (The basic CubeSat unit is 10 centimeters on a side and up to 1 kilogram in mass.) The Pocket Cube takes the CubeSat concept down a notch, just 50 millimeters on a side ... that is 1/8th the size of the CubeSat! Okay, so now Bob had my attention, and I wanted to see if a satellite that small could actually do something useful ... and I also thought that the Pocket Cube would be a good addition to the portfolio of resources that I am developing for the classroom (another inspirational "WOW" component). Below I will describe the Pocket Cube Simulator that is the result.

Besides the obvious physical size challenge of the Pocket Cube and trying to stuff some meaningful electronics into the tiny space, there is the challenge that a cube 50mm on a side limits the amount of solar panel surface available to generate power. I had also been looking for an excuse to explore a new set of RF modules called XBee [2], and the Pocket Cube gave me that excuse (At least in my own mind, however my wife will never be so convinced. Come to think of it, back a few years ago it took something a bit more curvy than a cube to get my motor running... ah the good ole days... miss 'em sometimes).

In the Pocket Cube simulator, I used the XBee module not only as the data link, but also as the microcontroller for measuring solar panel and battery voltages and for interfacing a "Sun" detector sensor. These units are small enough to fit inside the 50 mm cube. I am not going to turn this article into an XBee product review, but I will describe how I used the modules to make the Pocket Cube a functional satellite simulator. The XBee RF modules provide transparent (serial line replacement) and Application Programming Interface (API) operations in one very powerful, and affordable module. The modules operate at 2.4 GHz and come in low and high power variants. The XBee modules have a number of programmable I/O ports, 10-bit ADCs, timers, sleep modes, are power output agile and can be address specific and networked. I will admit the

documentation is a bit sparse (even at 60+ pages) and the learning curve for these modules is a bit steep, but once you get the hang of the module capabilities, you will be amazed at how flexible and powerful they are. (If you would really like my assessment on the device documentation, ask me off line, but be prepared for a few expletives thrown in for emphasis.)

The circuit that I use in the Pocket Cube Simulator is depicted in Figure 1. There are four small 6.7 volt solar panels mounted to the sides of the cube. The voltage divider across each panel provides a stepped down sensed voltage to a level compatible with 3.3 volt Vcc power and reference voltage source of the XBee modules. The capacitors provide some noise filtering on the ADC line. The diode keeps the battery current from reversing into the solar panels when the voltage on the battery exceeds the voltage produced by the individual solar panel. This approach may not be elegant, but it works. The same voltage divider circuit is connected across the NiCad battery. The battery provides power when the solar panels and the satellite are in eclipse.

The Sun sensor consists simply of a photo resistor that is connected to an I/O pin with a pull up resistor. When the photo resistor is exposed to the Sun, the resistance decreases and produces a "low" state on the I/O pin and the computer program that is monitoring the satellite telemetry responds accordingly (more on the command program in a minute).

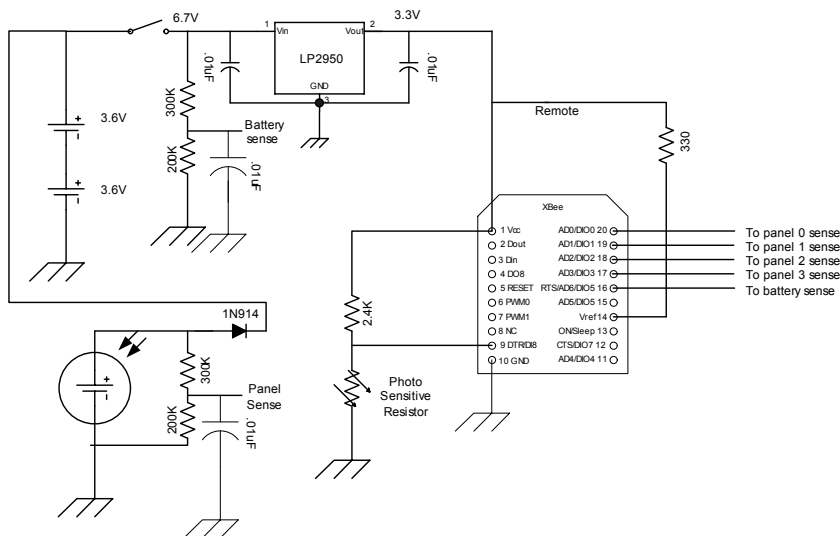


Figure 1: Schematic.

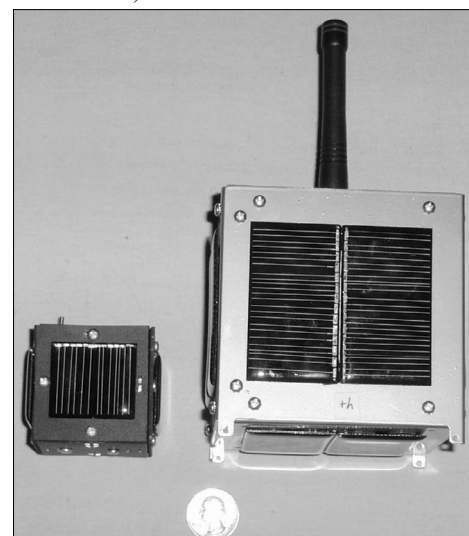


Photo 1: Pocket Cube (left) and CubeSat (right) Simulators.

Five of the 10-bit ADC resources of the XBee are programmed to measure the voltages of the solar panels and the battery, one I/O resource is programmed to sense the photo resistor (sense if the cube side is facing the Sun). The XBee module is programmed to enter the sleep, or power down, mode and wake up every 2 seconds to read and report the ADC channels. The module is also programmed to send a data stream when the Sun sensor is triggered.

The Pocket Cube structure is made out of scrap plastic from some used project enclosures. I epoxy glued the components to the inside cube surfaces “dead bug” style and I used wire wrapping techniques to make connections ... not pretty, but it worked for the prototype and proof of concept. Table 1 lists the major parts that I used in the project. I am considering designing a frame made out of circuit board material to make the project more easily duplicated if it proves a useful school resource.

On the simulated ground station side of the Pocket Cube simulator system, I use another XBee module that is connected directly into the USB port of the computer. I have authored a Visual Basic based program that displays all the data fields transmitted in the XBee packets and that also graphically depicts, with sliders, the relative voltage levels of the solar panels and the status of the Sun sensor. During operation, the Pocket Cube sends out a data stream every 2 seconds (or sooner if triggered by the Sun) and the VB program display is updated. As the satellite is rotated around its axis, the variation in the solar panel outputs are clearly indicated. By the way, there appears to be ample power generated by the solar panels when exposed to window lighting to keep the battery topped off and the satellite operational ... though I haven’t stressed the system to the limits (remember this was supposed to be a fun project).

So, was it fun? You-bet-cha. I actually had a blast dealing with the challenges of size and power limitations. I have convinced myself at least that the Pocket Cube concept is viable. These tiny satellites probably will not communicate with terrestrial ground stations in my lifetime, but they certainly will be capable of communicating with the “mother CubeSat” in the orbital vicinity in space. And finally, think of the “WOW” factor when you have someone in your audience say, “I can’t believe that the satellites are so small.” and you pull your Pocket Cube out of your

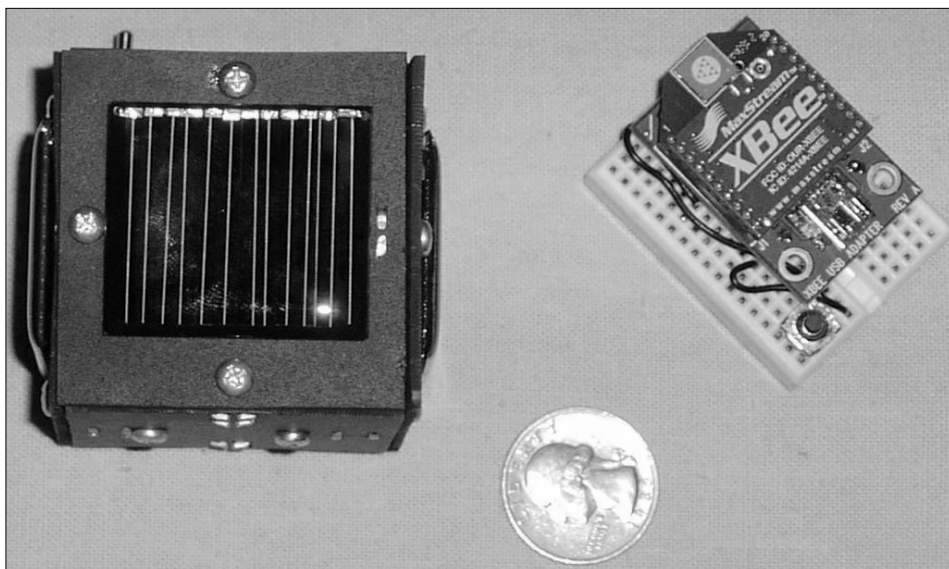


Photo 2: Pocket Cube with the XBee based ground station component.

pocket and say, “If you think that’s small, check this out!”

I welcome the chance to share the information I have on this project with a simple e-mail request. Just remember the material is not polished ... it was just supposed to be for fun. Mark Spencer, WA8SME, mspencer@arrl.org. CU on the birds.

References

- [1] <http://spacefellowship.com/news/art14006/satellite-pioneer-joins-morehead-state-s-space-science-faculty.html>
- [2] <http://www.digi.com/products/wireless/point-multipoint/xbec-series1-module.jsp#docs> 

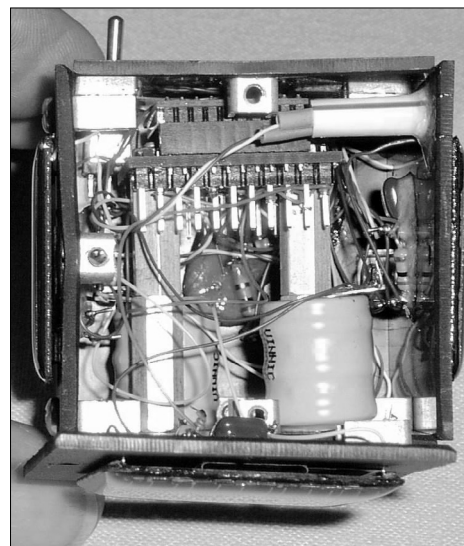


Photo 3: Inside the Pocket Cube.

Part	Supplier	Number
XBee Module	www.parallax.com	32404
XBee Carrier Board	www.parallax.com	32403
XBee USB Carrier Board	www.parallax.com	32400
Solar Panels	www.hobbyengineering.com	H01660-01DV2
Metal Fasteners	www.mouser.com	534-7774

Table 1: Parts list.

AMSAT at Dayton 2010

by Alan Biddle, WA4SCA, wa4sca@amsat.org

The Dayton Hamvention is always a fascinating mixture of the expected and the surprising. This year was no exception, especially for AMSAT. While several members of the ARISSat-1 team were absent working on that project, we had an abundance of AMSAT hardware to demonstrate, as well prototype CubeSat hardware showing the first results of a new collaboration between AMSAT and Binghamton University. The addition of speakers at the AMSAT Forum on the K4T DXpedition, and a report on the AMSAT-Binghamton University collaboration, demonstrated why 2010 is truly the year of "Space Technology for Hams."

The expected began with converting empty space at the Hamvention into the professional presentation seen by the visitors. This was a major exercise in logistics getting the stored booth materials together with exhibits and products. As usual, most of the booth wranglers arrived Wednesday afternoon and evening, bringing with them or picking up various components and exhibits. Thursday morning, a group departed to the storage facility with a van to bring the booth components to the Hara Arena, where they were met by others to assemble the tables, displays, computers, and hang the AMSAT banners and posters. With years of experience, the AMSAT booth went from chaos to the functional layout in about 8 hours.

The setup crew, many of whom also

worked many hours during the Hamvention, included Walt Wittenberg, K0CEH; Gould Smith, WA4SXM; Barry Baines, WD4ASW; Steve Belter, N9IP; Dee Interdonato, NB2F; Drew Glasbrenner, KO4MA; Wilse Morgan, WX7P; Chuck Pinkum, K3PER; Keith Baker, KB1SF/VA3KSF; Dave Taylor, W8AAS; Joe Prokop, KC8RAN; Mike Young, WB8CXO; John Shew, N4QQ, and as always, Martha. Local DARA support was indispensable to making this all work in light of some of the unique exhibit requirements. Nancy Makley, KC8GYW; Ed Collins, N8NUY; and DARA President Steve Coy, K8UD, smoothed the path for us and even dropped by to help out during the Hamvention at various times.

As in the past few years, our booth was located adjacent to the extensive ARRL exhibition and a quick walk from the satellite contacts demonstration area. It was divided in roughly equal parts for sales, satellite tracking software and hardware demonstrations, and the engineering section. The first two sections, except for changes in the items being sold, were relatively unchanged from past years. However, this year the sales area did feature a large bowl for contributions to the DARA matching fund drive. Approximately \$1000 was raised in small contributions.

New and Revised Items at Dayton 2010

- *AMSAT, The First Forty Years* by Bill Tynan, W3XO
- Revised 2010 *Getting Started with*

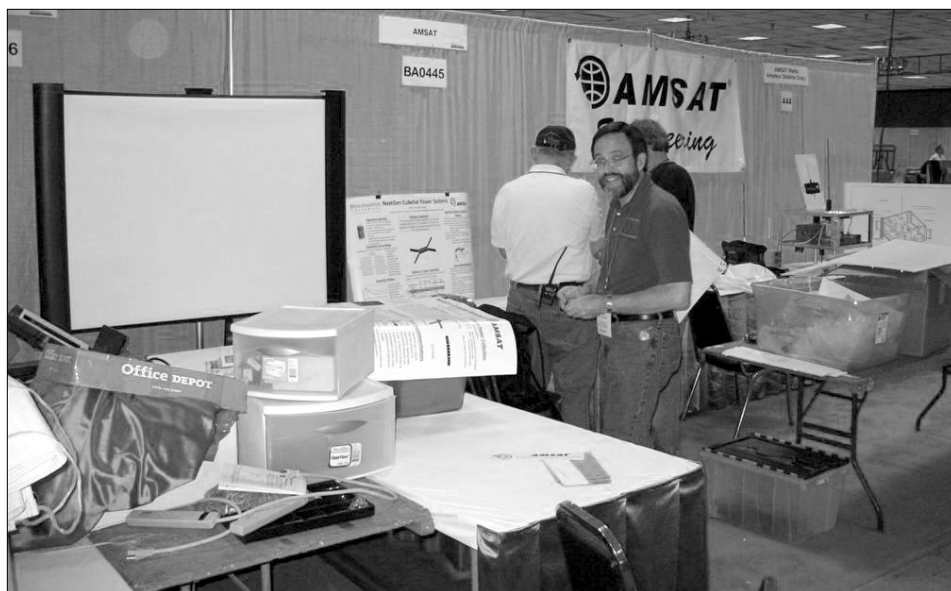
Amateur Satellites

- Updated 2010 *Amateur Satellite Frequency Guide*
- ARISS patches and decals
- The latest versions of SATPC32 and MacDopplerPRO
- AMSAT measuring tapes
- The dual band Elk antenna and matching transportation bag.
- New AMSAT clothing including tan golf shirts and red baseball caps with the AMSAT logo, and gold T-shirts with the ARISSat-1 logo.
- The LVB Tracker, with latest firmware, in both partial and completed form, courtesy of Mike, WB8CXO.

If you missed anything, most items can be ordered from the AMSAT Store at the Web site.

The engineering area changes radically from year to year reflecting current projects, and this year was no exception. There were two principle displays. The first was the engineering model of ARISSat-1, the follow-on to the SuitSat-1 project. In addition to being open for examination and handling, it was sending data to a demonstration ground station. The satellite demonstration outside was also able to use its transponder function for a simulated contact. Sharing space with ARISSat-1 was the NextGen 3U CubeSat Project. This included, in addition to excellent illustrations, the prototype hardware for a new power storage system using the new generation of pseudo capacitors rather than traditional storage cells. Pseudo capacitors, unlike the conventional storage batteries flown on previous spacecraft, have the potential for an effectively unlimited service lifetime. Also on display was a 3U CubeSat structure with an innovative thermal release system to deploy solar cell panels for increased power generation.

About a 2 minute walk from the AMSAT booth was the satellite station demonstration area. Each year Keith, W5IU, goes to many hamfests to demonstrate how easy it is to get on the satellites. He uses basic rigs, and a variety of commercial and homebrew antennas. Many are hardware store specials consisting of a few dollars of wire, wood, PVC tubing, and miscellaneous clamps and other hardware. Needless to say, this provides an eye opening experience for

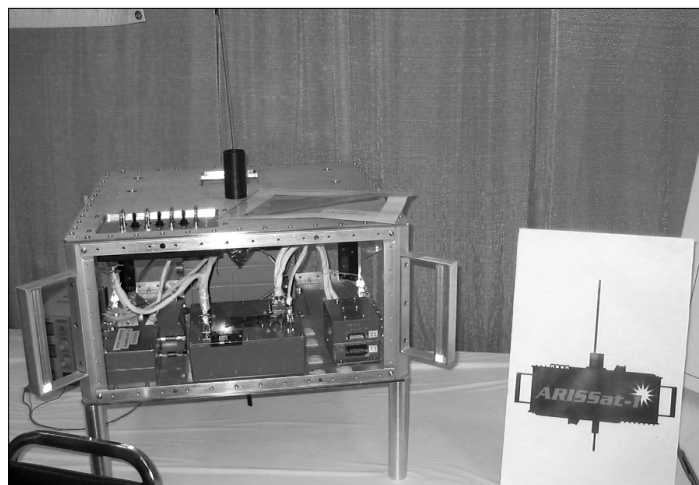


Some assembly required!



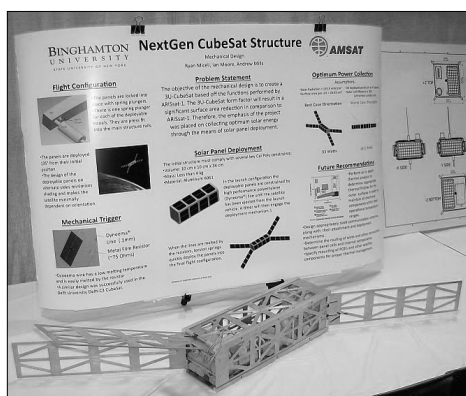


Engineering area showing both the current ARISSat-1 and future projects.



Engineering model of ARISSat-1 and logo.

many who have not been exposed to satellite operations before. This year at Dayton was no exception, with several pileups waiting to work the Hamvention, including a station in Greenland. Keith as usual had a steady stream of Armstrong rotator assistants to handle the pointing of the antennas while he did the operating.



Binghamton University-AMSAT project for a 3U CubeSat having deployable solar panels.

Hamvention 2010 booth volunteers included Don Agro, VE3VRW; Barry Baines, WD4ASW; Steve Belter, N9IP; Robert Felt, KB5YZG; Drew Glasbrenner, K04MA; Rick Hambly, W2GPS; Dee Interdonato, NB2F; Tom Clark, K3IO; Roger Ley, WA9PZL; Wilse Morgan, WX7P; Chuck Pinkum, K3PER; Keith Pugh, W5IU; Douglas Quagliana, KA2UPW; Larry Brown, W7LB; John Shew, N4QQ; Dave Taylor, W8AAS; Mike Young, WB8CXO, and Martha Saragovitz. As always, we could not function without the help of volunteers. If you have time next year, as little as two hours, drop by and join the fun. We provide on the job training! It is a great opportunity to put faces to names, and share the fun and experience with new or potential satellite operators.

Enthusiasm is contagious. Who knows, the volunteer next to you may be an astronaut or the DARA President!

AMSAT had a variety of social events in Dayton, both planned and unplanned. As usual, AMSAT members and friends gathered at the Tickets Pub and Eatery in Fairborn after the booth was assembled, around 18:30. They provided a separate room where everyone had a chance to relax and refresh after the day's efforts and catch up with people whom they may have not seen since last year. We expect to return again next year. All are welcome, whether you arrive in time to work on the booth or not!

Friday night, over 100 members attended the joint TAPR/AMSAT dinner held at the Kohler Presidential Banquet Center in Kettering. We began with cocktails and conversation, followed by an excellent buffet dinner. Many topics were productively discussed. Barry, WD4ASW, was this year's moderator. He reminded us of the TAPR/AMSAT community members who had become Silent Keys over the past

year. Afterwards the featured speaker, Bob McGwier, N4HY, guided us through a uniquely personal history of the development of DSP technologies, and especially Software Defined Radios. He emphasized the many times and ways both our organizations and individual hams contributed to this development. The audience came away with

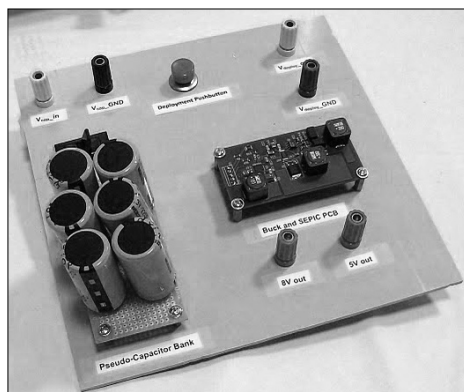


DARA President Steve Coy, K8UD, (c) stops by to talk with AMSAT President Barry Baines, WD4ASW, (r) and Vice-President Gould Smith, WA4SXM (l).

not only a better understanding of how this particular technology developed, but how often seemingly minor decisions and events can have significant consequences.

Saturday night usually has no specific AMSAT functions, but this year there was an unofficial gathering with members of one of the newest AMSAT organizations, AMSAT-TR. Turkish satellite operators had a large contingent at Dayton this year, and invited several officers of AMSAT-NA to dinner and a good chance for to get acquainted.

The AMSAT Forum this year included 5 speakers, covering the usual topics about AMSAT operations and plans, but also new developments for future spacecraft, and an innovative DXpedition emphasizing satellite



Binghamton University prototype of a satellite power supply using pseudocapacitors rather than conventional storage batteries.



Roger Westgate, WC2R presents the initial results of the AMSAT-Binghamton University NextGen CubeSat collaboration.

operations. The 2:15 allotted was adequate for the talks, but only just. As usual, the room was filled, with several standing around the walls. The peak count was 187. A surprise "Decade at Dayton" award for contributions to the AMSAT presence at Hamvention was presented to Barry, WD4ASW, and Keith, W5IU. Appropriately, this had to be carefully coordinated between forum presentations and satellite demonstration passes. We were also pleased to have DARA President Steve Coy, K8UD, address the forum.



Mike Forsythe, AC2V, giving a lively presentation of satellite operations on the K4T DXpedition.

Barry Baines, WD4ASW: "AMSAT Status Report." AMSAT President Barry Baines highlighted current activities within AMSAT and discussed some of the challenges facing the organization.

Drew Glasbrenner, KO4MA: "AMSAT Satellite Operations and International Satellite Operations". Drew, AMSAT VP of Operations, discussed operational AMSAT satellites as well as updates us on new and future International Satellites.

Mike Forsythe, AC2V: "Integrating Satellite Operations into DXpeditions" Mike, K4T Team Leader, presented the K4T DXpedition and how to have satellite

operations as a major part of DXpeditions, involving youth, and making it all work on green power!

Gould Smith, WA4SXM: "Getting ARISSat-1 Ready to Fly." Gould is the AMSAT Project Manager for ARISSat-1 and talked about the current status of the satellite project, testing and the delivery of two satellites to Russia in July.

Alex Harvilchuck, N3NP: "NextGen CubeSat Program Update." Alex, a Systems Engineer with IBM, is the NextGen CubeSat Program Manager and will be providing an update on the Program. A team of Binghamton University engineering students have been modifying the power systems from ARISSat-1 for use in a 3U CubeSat, with a U/V linear transponder, for AMSAT. (Presented by Roger Westgate, WC2R)

After the talks, a brief Q&A session was conducted by Barry, WD4ASW. He also introduced the AMSAT-TR representatives to a round of applause. Through the combined efforts of Steve Belter, N9IP, Douglas Quagliana, KA9UPW, and Patrick Stoddard, WD9EWK, the presentations, forum discussions, and TAPR/AMSAT dinner speech will be available at WWW.AMSAT.ORG. They will be archived under AMSAT Video News.

This was another highly successful Hamvention for AMSAT, aided by the uncharacteristically good weather and solid Hamvention turnout. In addition to all the meeting and discussion opportunities, we brought in \$21,806 at the booth. This is about 7% higher than last year, and very consistent with the reports from the rest of the Hamvention. We had 22 new members, 117 renewals and 3 new life members, and the usual hordes of gawkers and visitors.

Of course, for AMSAT as with any exhibitor, the Hamvention was not over until long after the attendees were well on their way home with their new toys. Finishing up the show included packing and shipping satellite components, certainly not a typical item, breaking down the booth, and returning its components to local storage to await Hamvention 2011. My thanks to Tom Clark, K3IO; Gould Smith, WA4SXM; and Keith Baker, KB1SF/VA3KSF for additional photos and reportage. ☺



Bob McGwier, N4HY, covers the history of DSP technology development, and the part played by TAPR and AMSAT members, at the annual TAPR/AMSAT dinner.



Drew Glasbrenner, KO4MA, briefs the AMSAT Forum on the status of current amateur satellites.



Gould Smith, WA4SXM, discusses the status and launch plans for ARISSat-1.



BOD Nominations Announced

It is my pleasure to announce that the following have been nominated to serve on the AMSAT Board of Directors for two year terms:

Tom Clark, K3IO

Lou McFadin, W5DID

Tony Monteiro, AA2TX

Gould Smith, WA4SXM

Candidates will be afforded the opportunity to have statements of their qualifications and positions circulated to the membership.

In accordance with the bylaws of the Radio Amateur Satellite Corporation, the ballots will be mailed no later than July 15th, and must be returned no later than September 15th to be counted.

Since there are four candidates for three seats, the three candidates having the greatest number of votes will be elected to full terms. The fourth candidate will serve as an alternate until the next annual election.

Alan Biddle, WA4SCA

AMSAT Corporate Secretary

AMSAT 2010 Space Symposium Adds Sunday FermiLab Supercollider Tour

The 2010 AMSAT Space Symposium and Annual Meeting will be held on Friday, October 8 through Sunday, October 10. This year we have selected the Chicago/Elk Grove Holiday Inn which is near O'Hare Airport for the event.

At the conclusion of the Symposium activities you are invited to participate in a tour of the Tevatron at the Fermi National Accelerator Laboratory on Sunday. Part of the tour will include a tour of the multi-megawatt RF portions of the particle accelerator as well as a tour of the new Super Conducting RF Test Facility. We will be arranging car pools for travel to FermiLab and back to the hotel. The planned start time for the FermiLab tour will be 12 Noon.

The 2010 Symposium Committee has completed the room reservation and registration details for the event. The hotel booking code for the Elk Grove Village Holiday Inn is AMS for the AMSAT convention. The \$79 per-night room rate will apply for those using this group code.

Watch the 2010 Symposium Web pages at <http://www.amsat.org> for the latest information.

The direct Web page link to the Elk Grove Village Holiday Inn is <http://tinyurl.com/22s788d> For people needing special accommodations please call the hotel directly at (847) 437-6010, ask for Brad. ☎

AMSAT is the North American distributor of SatPC32, a tracking program designed for ham satellite applications. For Windows 95, 98, NT, ME, 2000, XP, Vista, Windows 7.

Version 12.8a is compatible with Windows 7 and features enhanced support for tuning multiple radios.

Version 12.8a features:

- Select 2D/3D map with a single mouse click
- Select Political/Physical map with a single mouse click
- AOS voice announcement
- Countdown program displays next AOS of your favorite satellites
- Automatic Internet download of Keplerian elements.
- Graphical tracking on a world map with two selectable Zoom factors.
- One-click satellite switching using 12 "letter" buttons.
- Automatic rotor control support for: LVBTracker, Kansas City Tracker/Tuner, FODtrack, Uni_Trac, SatEL, Labjack U12/U3/Piggyback, W0LMD Mini/Junior/Senior Trackers, Yaesu GS-232, ARS from EA4TX, EGIS rotors, IF-100, RIF-PC, AMSAT-DL interface, WinRotor32, HalloRotor, and WiSP DDE clients.
- Doppler tuning with on-screen frequency displays. Radio models supported:
 - Yaesu FT-847, FT-736R, FT-817, FT-857, FT-897
 - ICOM IC-820H, IC-821H, IC-910H and other ICOM radios
 - Kenwood TS-790 and TS-2000
 - DDE client programs
- "Transparent" VFO-knob tuning in addition to keyboard and mouse tuning.
- "Virtual" VFO tracking for half-duplex transceivers FT-817, FT-857, FT-897, IC-706 and IC-7000.
- Includes a special version for ISS split-frequency operation.
- Controls subaudible tone on FT-847, FT-736R, FT-817/857/897, TS790A and IC-910H.
- Includes a non-graphical version and programs that output lists to the screen, printer, or a file.
- Interfaces with WiSP, with user-defined satellite switching priority.
- Includes a separate program for tracking the Sun and Moon.

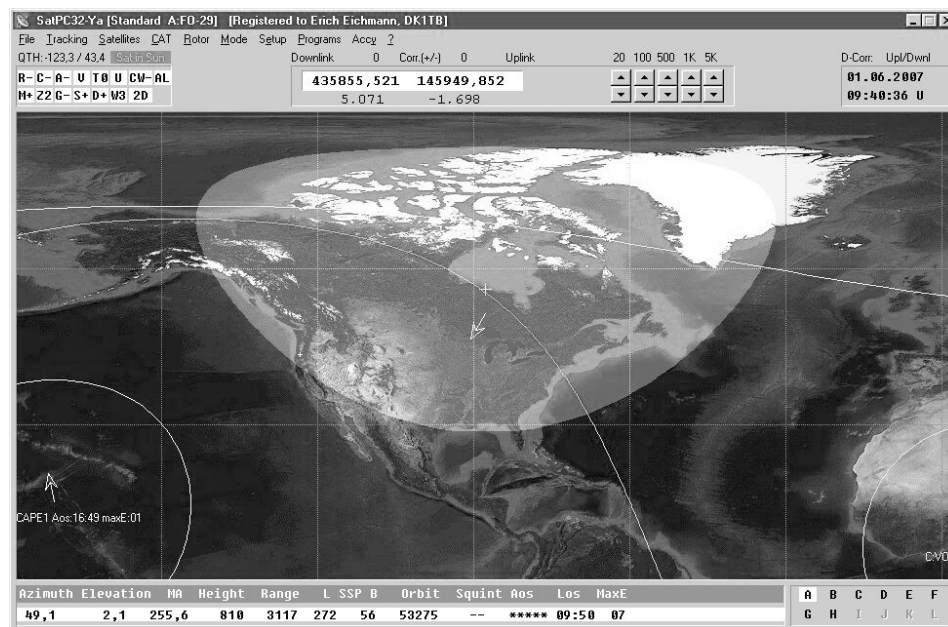
Minimum Donation is \$45 for AMSAT members, \$50 for non-members, on CD-ROM.

A demo version may be downloaded from <http://www.dk1tb.de/indexeng.htm>

A registration password for the demo version may be obtained for a minimum donation of \$40 for members and \$45 for non-members.

Order by calling 1-888-322-6728.

The author DK1TB donated SatPC32 to AMSAT. All proceeds support AMSAT.



Medium Earth Orbit - An Affordable Alternative to HEO?

by David Bowman, G0MRF, g0mrf@aol.com

Abstract

This paper examines the communications potential for an AMSAT spacecraft located in Medium Earth Orbit (MEO) and poses the question, "Is MEO an affordable and acceptable alternative to the traditional High Earth Orbit P3 series?" The paper considers the increased RF path loss on system design and the implications of operating in a higher radiation environment. It concludes by examining methods of achieving orbital transfer from LEO to MEO and outlines a possible compromise between fuel mass, launch cost and apogee height.

This is an updated and abridged version of a paper first presented at the AMSAT NA symposium in Atlanta 2008.

Background

At this time, AMSAT does not have a satellite in orbit capable of routine intercontinental communication. It has been 9 years since the last launch of an AMSAT high earth orbit spacecraft and 6 years since the loss of AO-40.

As an organization, AMSAT is blessed with having industry professionals and many highly skilled and capable individuals. AMSAT has built working relationships with many organizations in the space industry and is respected. But, in the world of 2009 (when this paper was written – Ed.), there are more satellites awaiting launch and fewer

launches per year than at any time in the last 20 years. Also, the affordable launches traditionally used by AMSAT came during the early proving flights of the Ariane 4 and Ariane 5 series from Kourou. Now Ariane 5 and the Soyuz launchers are technically mature and reliable designs. If you want to fly to Geostationary Transfer Orbit now, you compete with commercial organizations and national governments paying the full commercial rate. The harsh reality is that the cost of launching a 150 kg satellite to GTO is beyond the reach of AMSAT alone.

Communication Range and Altitude

The current fleet of LEO spacecraft carrying Amateur Radio has a typical altitude of 700 km and are frequently launched as secondary payloads with other satellites into Sun synchronous orbits. Of these satellites carrying Amateur Radio, the International Space Station, ISS, at 350 km has the lowest maintained orbit. In addition to the ARISS equipment onboard the ISS, there have been several satellites carrying Amateur Radio deployed from the space station. All of these, including Suitsat 1, which inspired the public imagination in 2006, quickly re-entered the atmosphere having descended to 170 km in 3 – 12 months.

Increasing in altitude we have the very popular AO-51 at 800 km, FO-29 at 1000 km, but the two highest LEO satellites operating in the amateur space allocation are

AO-7 launched in December 1974 and the recently launched RS30, which both have similar altitudes at 1500 km. It is unfortunate that RS-30 appears to only contain a beacon serving a small number of individuals within the organizations responsible for its construction.

The ISS and AO-7 represent the lower and upper limits of satellites carrying Amateur Radio in Low Earth Orbit, but even these LEO satellites have a widely different communication range.

The maximum range across a satellite's footprint can be calculated using the formula:

$$\text{Max range} = 2R \arccos(R/(R+h))$$

Where R = radius of the Earth, h = height of satellite, R = 6371 km (spherical model)

Solving for various satellites and orbits we find (shown in Table 1):

Looking at the maximum ranges calculated we see that the ISS has a typical limit for communication across the footprint of 4130 km, but for AO-7 the distance approaches 8000km. This is just enough for some enterprising radio amateurs to enjoy the thrills of intercontinental communication. Clearly the higher the apogee the better. Note that at 13,000 km you have 87% of the range offered by P3e.

Medium Earth Orbits

The medium earth orbits shown in the table above have excellent DX potential compared to a LEO. But how far above the earth should the satellite be? The figures above of 7000 and 13,000 km altitude have not been chosen at random. Potentially, there are two areas that can be used for MEO. The first is at 20 – 23,000 km which is currently populated with satellites providing global positioning signals. As these satellites are essentially military, it is unlikely that the launch agency responsible for GPS launches would accept secondary payloads. But having said that, the option of a direct launch to MEO should not be completely discounted. Below 20,000 km are two radiation belts. The Van Allen belts are separated into two layers. The lower layer is comprised of high energy protons between 600 and 6000 km. The second radiation belt comprises high energy electrons that occupy altitudes from 13,000 to 18,000 km. So any 'MEOSAT' could avoid damaging radiation by orbiting in the "safe zone" between. 6000

Satellite	Altitude (km)	Maximum communication range (km)
ISS	350	4130
AO-51	780	6006
AO-7	1500	7997
MEO	7000	13687
MEO	13000	15745
MEO	20000	16800
P3e	36000	18091

Table 1: Satellite altitude and estimated range.



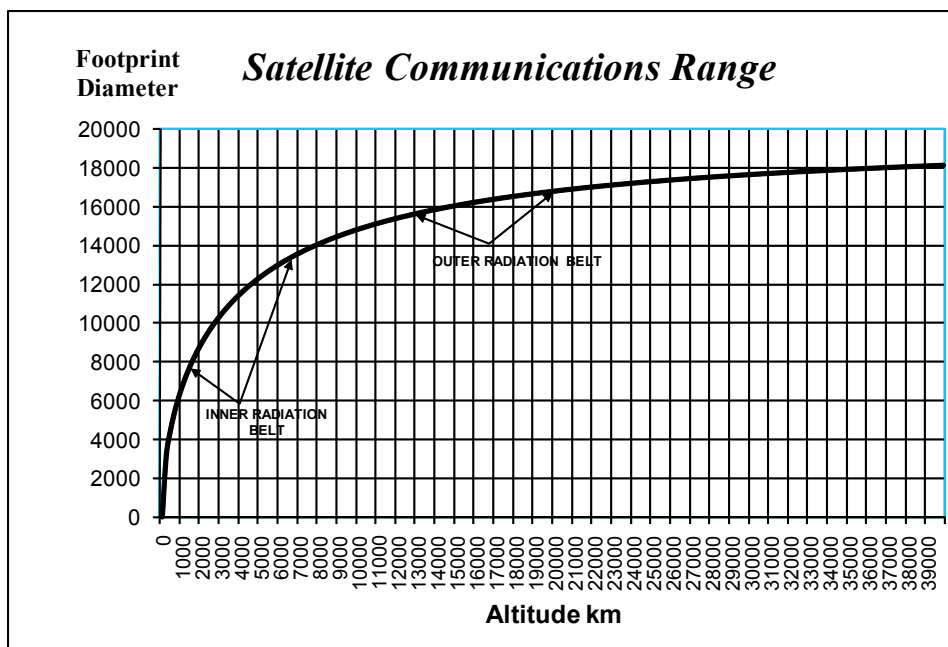


Figure 1: Altitude and satellite footprint diameter including radiation belt altitudes.

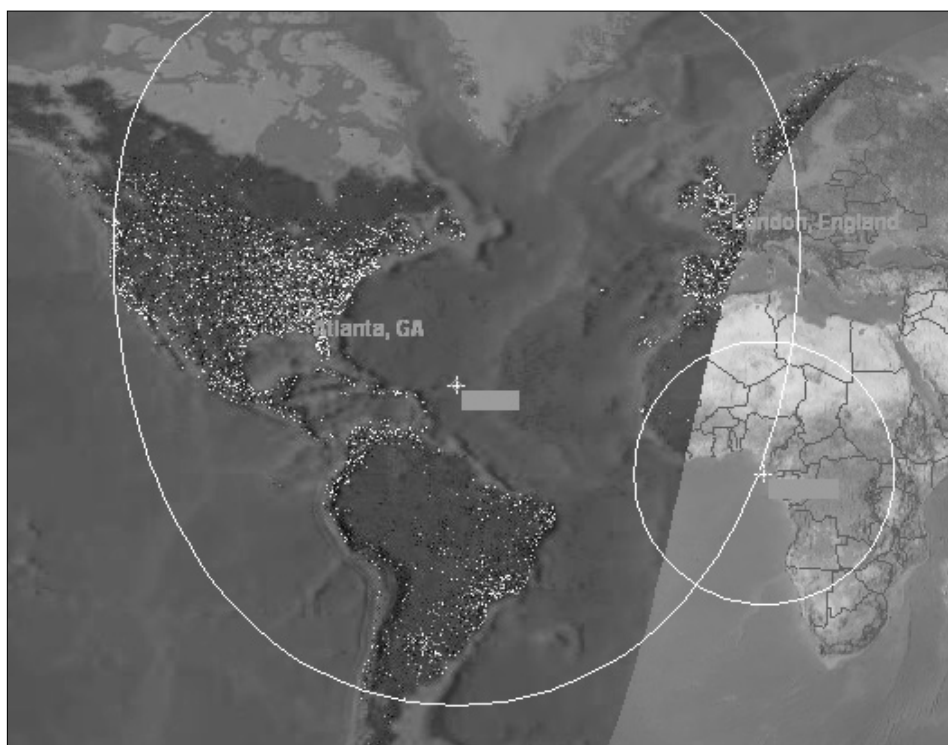


Figure 2: Footprint of a Medium Earth Orbiting satellite at an altitude of 7200 km along with the footprint of AO-51.

and 13,000 km.

Figure 2 shows AO-51 at 780 km and MEOSAT at 7200 km. At 7200 km a typical overhead pass from MEO lasts not for the 12 or 15 minutes of a LEO satellite, but a full 90 minutes. The communications potential across the footprint is equally impressive:

- California can communicate with Western Europe.
- Italy can work into Western Australia (just)

- Northern Finland has a mutual path with Capetown, South Africa.

A satellite at an altitude of 7200 km orbits 5.5 times in a 24 hour period. This is its mean motion.

Van Allen Radiation Belts

In 1958, experimental results from Explorer 1 and Explorer 3 led to the discovery by James Van Allen of the radiation belts which now bear his name. Unfortunately, their high energy charged particles cause the rapid

failure of sensitive electronic components. The radiation intensity increases with altitude and although there is a well documented hot spot known as the South Atlantic anomaly which extends down to 200 km, it is generally accepted that Low Earth Orbit is relatively benign below 1000 km. However, above approximately 1500 km lies a hostile radiation environment in which the long term reliability of spacecraft electronics is very doubtful. Indeed, the control electronics onboard AMSAT Oscar 10 failed from radiation damage following an orbital manoeuvre that left it in the radiation belts for a higher percentage of its orbit than planned.

Figures 3a and 3b at the top of the next page illustrate the geometry of the Van Allen radiation belts. Both belts are centered over the equatorial region and are doughnut shaped. Spacecraft therefore experience a higher intensity of ionizing radiation over the equator than they experience over the higher latitudes of the planet.

The polar regions have the lowest radiation levels from the Van Allen belts, but suffer from high energy cosmic rays which travel along the Earth's magnetic field lines.

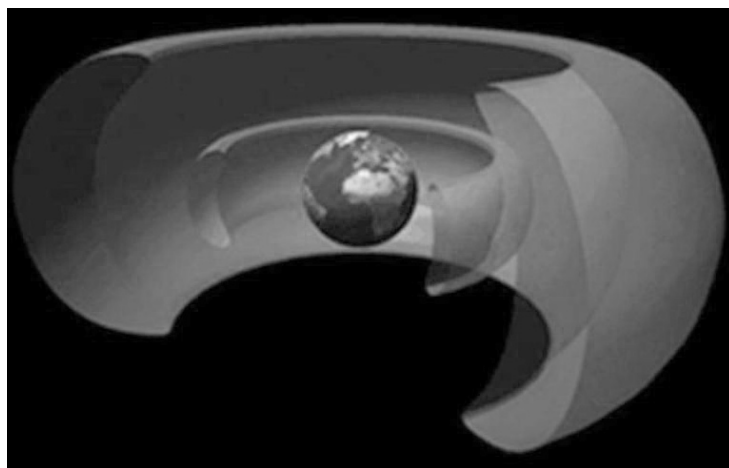
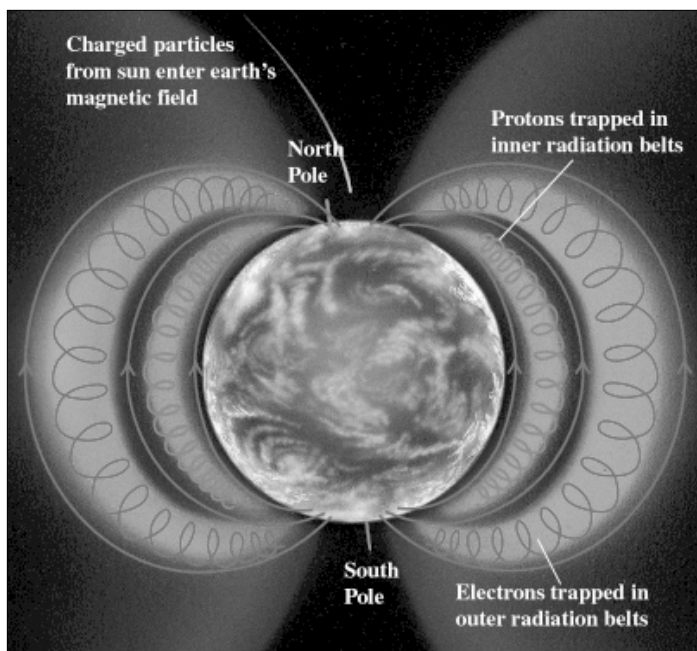
The lower belt of protons is relatively well defined with an upper altitude of 6000 km. However, the upper radiation belt is subject to fluctuations in the Earth's magnetic field. Its position can vary with solar storms and with the eleven year sunspot cycle.

Given the position of the radiation belts, a high inclination orbit offers significant advantages over a more equatorial low inclination orbit.

The geometry of the Van Allen belts present several possibilities for satellites carrying communication systems operating in the Amateur Radio space allocation:

- To fly as close to the lower belt as the electronics will allow – 1500 km to 2000 km. This could be a circular orbit or an elliptical orbit.
- A circular orbit within the safe zone at 7000 km just above the lower belt.
- An elliptical orbit from LEO to an apogee at 13,000 km just below the upper belt
- Just above the upper belt at 20,000 to 23,000 km

It is possible to reach the first 3 of these orbits with a satellite equipped with propulsion that has been launched into a high inclination low earth orbit.



Graphical representation of the VanAllen radiation belts surrounding the earth. High energy particles can damage spacecraft electronics when they are in these regions.

Figure 3a: Image left – Addison Wesley Longman Inc.
Figure 3b: Image above – NASA jgc

Although a circular orbit at 7000 km would represent a conventional choice, the elliptical orbit option is worth further examination. It is an orbit that can be reached with a single burn from LEO and although the orbit will pass through the lower radiation belt 9 times every day, the amount of time it is within this harsh environment is surprisingly small.

The following Keplerian element set shows the characteristics:

Epoch time	8247.41722406	Argument of perigee	173.087000
Inclination	98.068600	Mean anomaly	267.182300
RAAN	267.68780	Mean motion	5.68000000

The orbit is elliptical with a period of 4 hours and 13 minutes. The apogee is just under 13,000 km and is in the upper part of the safe zone between the two Van Allen radiation belts. Perigee is at 780 km which is a typical height for a LEO launch. Analysis of the orbit with respect to Van Allen belts shows that the satellite spends just 19 percent of its time between 2000 and 6000 km, and that some of this time is in the areas of high latitude.

Total orbital period: 253 minutes
Time below 2000 km: 28 minutes (11%)
Time between 2000 km and 6000 km (radiation belt): 48 minutes (19%)
Time from 6000 km – apogee – 6000 km: 177 minutes (70%)

Reliability and Lifespan

Radiation hardened components are expensive and in the past history of AMSAT are rarely used. A notable exception was

the COSMAC 1802 processor used in the early Phase 3 series. If a flight to MEO is undertaken, then mitigating the radiation hazard is essential. Aluminium and tantalum shielding can provide a physical barrier, but processors and control electronics probably need to be replaced by a radiation tolerant FPGA. It is also worth remembering that the AO-7 transponder continues to function after absorbing a large total dose following 34 years at 1500 km. Similarly, AO-10 provided many years service after all ability to control its attitude was lost due to radiation damage.

Medium Earth Orbit Communications Link Budget

What equipment would be needed to operate a satellite in MEO? Let's compare AO-51 at 750 km, AO-40 at 50,000 km and a satellite in medium earth orbit (see table below).

Satellite	Height (km)	Elevation (degrees)	Range (km)	2m Path Loss	70cm Path Loss
AO-51	750	15	2000	142dB	151.4dB
AO-40	35000	xxx	50000	169.7	179
MEOSAT	7200	25	15000	155.4	165

Mode UV – Downlink

A typical LEO with a 100 kHz linear transponder runs 1 watt on 145 MHz to a simple antenna (1W ERP) and can be received at the groundstation on a small handheld beam of 2 or 3 elements having a forward gain of perhaps +4 dBd. We can see that MEOSAT has 13 dB more path loss on

2 m compared to AO-51 and so would need to have an output power +13dB or 20 watts to a similar antenna to be received on the same small beam.

However, 20W is too high for this idea! Other choices would be to reduce the transponder bandwidth, use a directional antenna with some gain on MEOSAT or increase the gain on the ground station receive antenna. To ensure the practicality of the concept, let's keep the omni antenna on MEOSAT but reduce the bandwidth by 50% and save 3 dB. Then we can save another 6 dB by increasing the output power from 1 to 4 watts. Now, instead of our -13 dB deficit we now have -13 + 3 + 6 = -4dB.

This final 4 dB deficit can be compensated for by increasing the gain of the groundstation antenna. By adding 4 dB, the required antenna gain is now +8 dBd, but that is still

a modest antenna for a system that is capable of routine intercontinental communication.

Mode UV - Uplink Power

For a mode U/V transponder, with an uplink on 70 cm and the downlink on 2 m, we can see the path loss is 13.6 dB greater than AO-51 but 14 dB less than the path loss out to AO-40. Without doing a full analysis



including receiver/antenna/path loss/filter and other losses, we can estimate the power needed by comparison with a typical AO-40 ground station.

AO-40 ground station UHF Uplink = 50W + 19 element Yagi. = 2 kW ERP.

MEOSAT = -14 dB + 6 dB for simple antennas = 2 kW – 8 dB = 320 W ERP (for a very good signal)

So a typical station may be a 30 watt radio and a small 70 cm Yagi of around 9 elements for a good SSB signal, while 5 - 10W should work for narrow bandwidth digital modes, e.g. PSK.

A full link budget analysis could be made using Jan King's Excel Link Budget Calculator. However, the approximation outlined above, even with some errors, shows that requirements for mode U/V from Medium Earth orbit are very modest.

Propulsion Technologies and Orbital Transfer

The following section looks briefly at methods of raising the altitude of a satellite from a typical LEO to higher altitudes. Achim Vollhardt, DH2VA, has produced an Excel spreadsheet [1] which calculates delta V required to reach a specific destination orbit. It examines the required propulsion capability of a satellite based on its mass, propulsion system and fuel load.

A Hohmann transfer (see diagram at lower left.) is a fuel efficient method to transfer from one circular orbit to another circular orbit that is in the same plane (same inclination), but at a different altitude. It requires two engine burns. The first places the satellite into an elliptical orbit where the perigee is the same altitude as the original LEO orbit and apogee is at the destination altitude. The second burn raises the perigee and circularises the orbit.

Propulsion Technology

Propulsion systems have been used on previous AMSAT satellites. AO-10, AO-13 and AO-40 all used a 400 newton bi-propellant engine fuelled by hydrazine and nitrogen Tetroxide. A similar 200 N thruster will be used on P3E. The fuels used on the phase 3 satellites are very hazardous and the use of dangerous compounds also means the control systems to operate a bipropellant engine are complex. So what other methods are there for generating thrust for a small satellite? The answer appears to include: cold gas thrusters, arc jet or resistojet techniques, mono propellants, solid fuel engines or electric/ion drive.

In April this year a number of presentations at the annual CubeSat Developers Conference at Cal Poly examined propulsion systems for CubeSats. Among the proposals was attitude

control using pulsed plasma thrusters using just 1.5 watts of DC power. Also presented was a paper by Chris Biddy and Dr. Thomas Svitek of Stella Exploration [2] detailing an advanced project capable of substantial orbital change using a 1U CubeSat structure to hold a 4 thruster monopropellant propulsion system.

The 1U propulsion module described by Biddy and Svitek can be fitted to a 2U CubeSat forming a satellite the same size as Delfi C3 / DO-64, but with a propulsion system capable of providing a delta V (change in velocity) of up to 400 meters/second. While the hydrazine monopropellant would not be sufficient to propel this CubeSat to medium earth orbit, a quick calculation shows that it is capable of raising the altitude from 600 km, which is typical for a commercial Sun synchronous LEO, to 1400 km circular. A second possibility would be to use all the fuel in the first part of the Hohmann transfer described above. This has the potential to produce an elliptical orbit with a perigee at the initial orbital height of 600 km, but with an apogee exceeding 2200 km. The elliptical orbit option has the advantage that with the correct perigee height the satellite would also meet the recent orbital debris requirements.

To design a system capable of LEO to MEO orbital transfer it is necessary to establish a compromise between satellite payload mass, fuel mass and engine efficiency which is referred to as ISP or specific Impulse.

With the aid of the spreadsheet [1] we can test ideas for a Hohmann transfer from 800 to 7000 km

Initial mass of satellite 25 kg; Initial LEO orbit at 800 km; Destination orbit 7000 km.

Delta V required for elliptical transfer orbit.
= $v_1 = 1050$ m/s

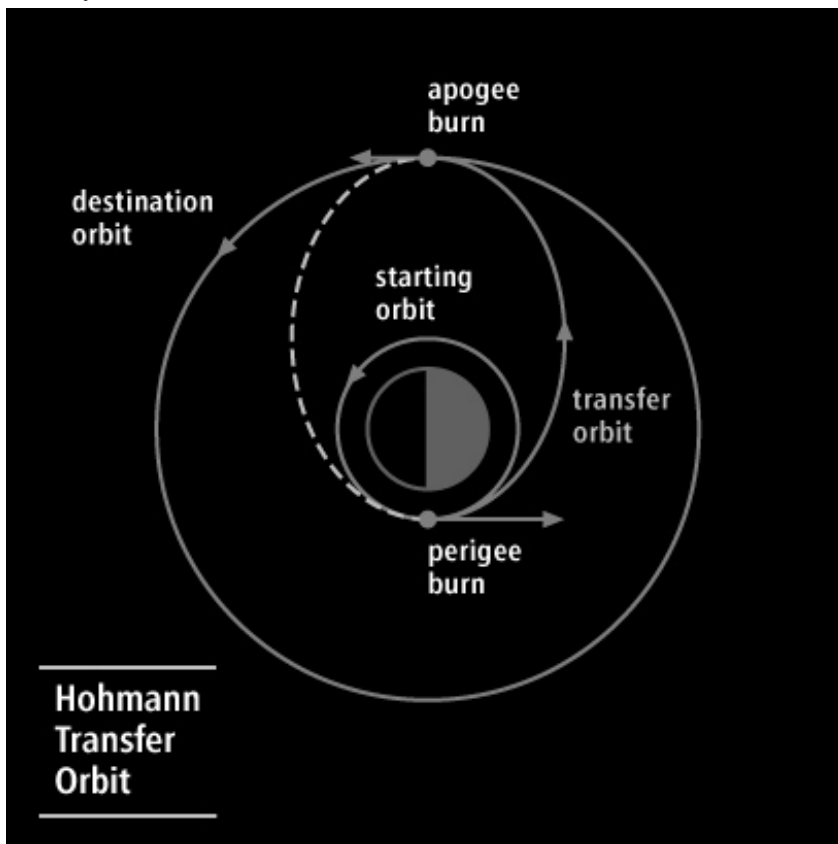
Delta V required for second circularizing burn = $v_2 = 897$ m/s; total $v_1 + v_2 = 1947$ m/s

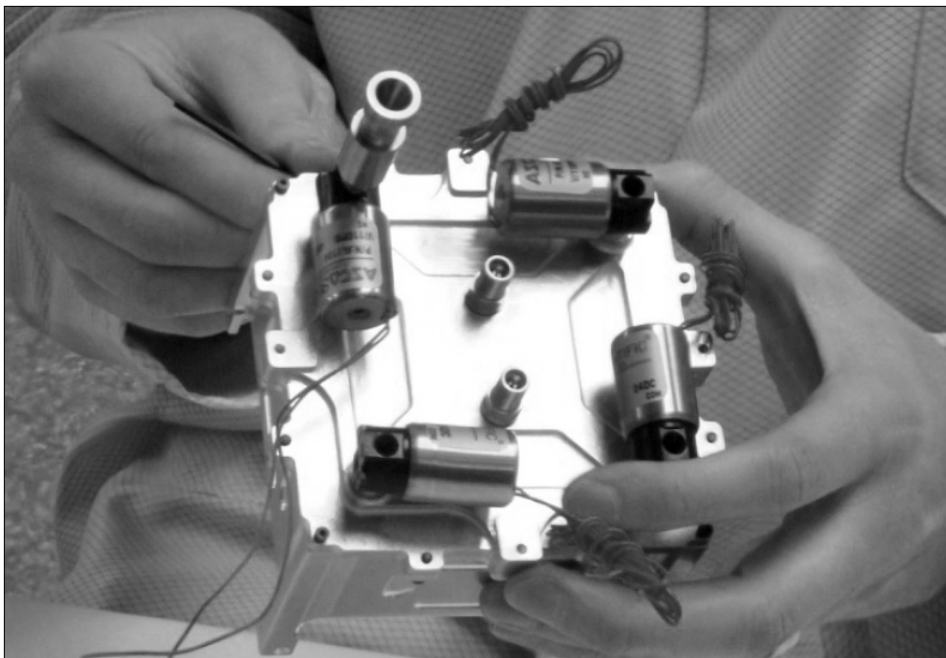
Mono propellant thruster Isp 220. - Mass of fuel required for $v_1 = 9.7$ kg; $v_1 + v_2 = 15.1$ kg

Bipropellant thruster Isp 280 - Mass of fuel required for $v_1 = 8.0$ kg; $v_1 + v_2 = 12.8$ kg

Hydrazine or NH₃ arcjet Isp 500 - Mass of fuel required for $v_1 = 4.9$ kg; $v_1 + v_2 = 8.8$ kg

It can be seen that using conventional bipropellant thruster requires around 50





Potential CubeSat propulsion system.

percent of the satellite mass to be used for fuel. However, with the high efficiency arcjet, the fuel mass is reduced to 36%.

The final example is for an elliptical orbit with an apogee at 13,000 km also using parameters for the arcjet.

Initial orbit – 800 km circular; Target orbit – 13000 km elliptical; perigee at 800 km.

Delta V required. = 1551 m/s; Mass of fuel required = 6.8 kg (27% of total mass)

With just 6.8 kg of fuel there would be adequate mass remaining for structure and payloads. One additional advantage of the arcjet is that should there be a technical failure, then the gas can be vented to space and the system operated as a cold gas thruster. While this is insufficient to reach MEO it could boost the orbit from 800 km to a more interesting LEO.

Launch Opportunities?

Low Earth Orbit is a popular destination for Earth observation, science and educational missions. There are however two new launchers due to come into service within the next year and these open the possibility of reduced cost launches during their initial proving flights. The Space-X Falcon 1 has had five flights from its base in Kwajalein in the Pacific. This launch vehicle is now entering the early stages of routine operation.

Meanwhile The European Space Agency is due to launch the maiden flight of Vega from Kourou in South America. Vega is the European's new low earth orbit launcher and

is scheduled for its maiden flight in 2010. The maiden flight payloads have already been selected and include 9 educational CubeSats from European universities. The CubeSat launch is being generously sponsored by the ESA Education Office. I am not aware of any other launch agency that has such a proactive and positive approach to supporting the study of space and technology education.

Following the maiden flight, Vega will have five VERTA flights. These are verification flights and applications are invited for payloads that will fully test the launcher's capabilities. Applicants are invited to contribute to the flight costs by offering a bid based on mass, required orbit and the degree of support required from ESA. The VERTA flights are scheduled to take place at intervals of six months from a successful maiden flight. An interesting aspect of the Vega program is that the upper stage has the ability to perform orbital manoeuvres between each satellite deployment. Following the final satellite deployment, the upper stage uses the remaining fuel to deorbit, thereby reducing the amount of space debris in LEO.

Partnerships and Collaboration

One aspect that may not have been fully explored by AMSAT is the possibility of entering into partnerships or cooperating with other organizations that have mutually compatible needs. Examples of this are the cooperation between the students at the Delft Technical University in The Netherlands and Dutch Space, which brought us Delfi

C-3 (DO-64) in April 2008. Also, the work by AMSAT-UK on SSETI Express (XO-53) and the ongoing ESEO educational projects may provide opportunities. Both of these add Amateur Radio functionality at the completion of a primary science mission.

For a possible launch on the VERTA flights of Vega it is unlikely that a purely Amateur Radio mission, despite the educational outreach possibilities, will be sufficiently appealing to any selection panel. However, a mission that includes orbital transfer to an interesting but unoccupied region of space in the safe zone, which perhaps included a newly developed arcjet propulsion thruster or pulsed plasma attitude control, would add much scientific merit and could be seen as a positive addition to any mission proposal.

References

- [1] http://gulp.physik.unizh.ch/meosat_propulsion.xls
- [2] http://mstl.atl.calpoly.edu/~bklofas/Presentations/DevelopersWorkshop2009/1_New_Tech_1/6_Biddy-Monopropellant_Propulsion.pdf



2010 Space Symposium & AMSAT-NA Annual Meeting

OCTOBER 8 - 9 - 10

CHICAGO

Space Symposium with Amateur Radio Presentations

Operating Techniques, News & Plans

Board of Directors Meeting open to AMSAT Members

Meet Board Members and Officers

Annual General Membership Meeting

Annual Banquet-Keynote Speaker & Door Prizes

President's Club Reception

Area Coordinator's Breakfast

NEAR O'HARE
AIRPORT!

Chicago-Elk Grove Village
Holiday Inn

1000 Busse Road
Elk Grove Village, IL 60007
847-437-6010

REGISTRATION
ON-LINE
WWW.AMSAT.ORG





LVB Tracker Box

- Reasonably priced and all profits go to AMSAT
- USB or serial interface
- Ethernet interface capable
- Open software
- Open architecture
- Built-in rotor interface cable with DIN connector
- Power supplied via the rotor controller cable
- Bi-directional interface allows the unit to read the rotor position
- LCD position readout
- Front panel manual control
- Self-programmable, allows for easy software upgrades
- Supported by the major tracking programs
- Uses GS-232A or Easycomm I/II protocols

Contact Martha at the AMSAT office 301-589-6062 to order.

The complete units will be built in groups, so get your orders in early. Units will be shipped as they become available.

Minimum donations requested for various configurations:

- 1) Bare board - \$20 + S&H - no parts kits available
- 2) Populated board, serial interface - \$100 + S&H - no kit with USB unit, rotor cable and LCD available, we do have a parts list with recommended part numbers and sources.
- 3) Custom Ten-Tec Enclosure powder coat, silk-screened, drilled/punched - \$50 + S&H
- 4) Complete unit - board, USB output, rotor cable, LCD, enclosure - \$200 + S&H **our most popular

Documentation for the LVB Tracker can be found at: <http://www.LVBTracker.com>

Boards and complete units may be ordered from the AMSAT office at 301-589-6062 or from martha@amsat.org

THE R.F. CONNECTION

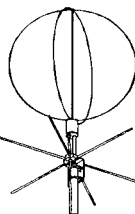
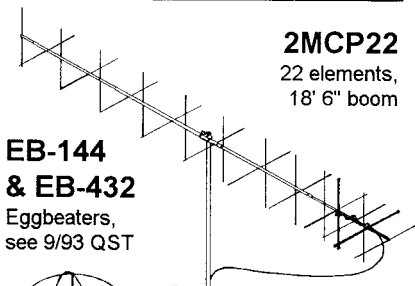
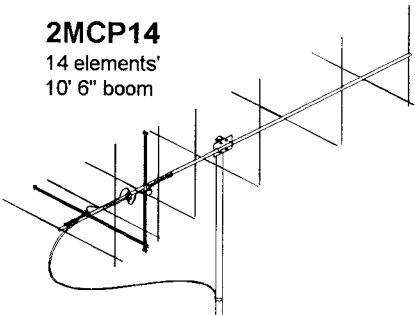
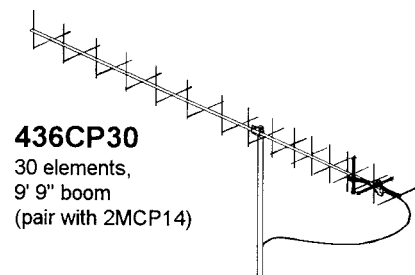
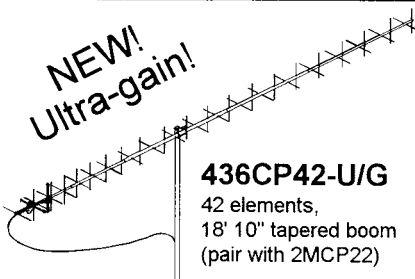
"Specialist in
R.F. Connectors and Coax"
<http://www.therfc.com>

301/840-5477
Fax 301/869-3680
E mail: rfc@therfc.com

Order Line 800/783-2666
Suite 11, 213 N. Frederick Ave.
Gaithersburg, MD 20877

M² YOUR SATELLITE ANTENNA SOURCE

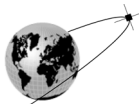
NEW!
Ultra-gain!



- Stacking frames
- AZ & EL positioners
- Fiberglass crossbooms
- Power Dividers
- Phasing harnesses

M² 4402 N. Selland
Fresno, CA 93722
(559) 432-8873 FAX: 432-3059





Apogee View - continued ...

of communication in addition to encouraging AMSAT-TR to work with European AMSAT organizations given the issues that we're facing with ITAR. AMSAT-TR's Web site can be found at <http://www.amsat-tr.org>. I was very impressed that the AMSAT-TR delegation of about eight individuals came to the U.S.A. to attend their first Hamvention as well as taking time to travel in the US. Congratulations to AMSAT-TR on the establishment of their new organization!

Progress continues on ARISSat-1. As I'm writing this column the week after Hamvention, we're on track for a NASA Payload Safety Review Panel meeting (which also includes representatives from RSC-Energia) on June 29 and June 30. Thermal vacuum testing continues and we expect to do vibration testing in June at Wallops Island, VA. The satellite team has spent untold hours working hard to bring this satellite to life as well as developing the ground station software so that schools and individuals can receive telemetry data from both the satellite and the Kursk State Technical University experiment. The export licensing process is complete, so we'll be able to ship the satellite and a spare (for crew training) with the proper government approvals. We are nearing the finish line for this project.

As noted in an earlier Apogee View column, AMSAT has deferred start of development work for Fox CubeSat until after ARISSat-1 is completed and shipped to Russia. The focus on ARISSat-1 has the undivided attention of our engineering leadership and that precludes progress on Fox. More details will be forthcoming on the project plan for Fox once our engineering leadership has had an opportunity to start planning work on the project. While we are disappointed that Project Fox will start later than originally expected, we must recognize the fact that AMSAT's limited engineering talent pool precludes working on projects in parallel. Until we can expand the engineering leadership talent pool and gain enough engineering talent to spread the workload around, we will be constrained. Hopefully, as Fox development proceeds we'll be able to recruit and train new talent that not only will help this project, but then be in position

Volunteer for AMSAT

Help Wanted

AMSAT needs qualified volunteers for a number of positions!

If you want to be a part of the solution in making AMSAT operational and work toward designing, building and finding a launch, WE NEED YOU!

No pay for 5+ hours per week, but a great deal of satisfaction in knowing you are helping make something happen.

We need people with these skills:

- Marketing
- Sales
- Software engineering
- Hardware engineering
- PC based software design
- Web design and maintenance
- Project management
- Documentation
- Hardware testing
- Software testing
- Hardware prototyping
- Specific area Web site information maintenance
- Video recording, digital conversion and editing
- Write technical or instructional material
- Educational activities
- Promoting AMSAT as an Area Coordinator



and any other area you think you think you can make a difference.

We often have people volunteer, but many don't deliver on their promises. So, pick an area that you think needs improvement and explain what you will do to make it better. Then do something to show that you can follow through.

Send your suggestions, actions plans and a description of why you are capable of doing this task to Gould Smith, WA4SXM, wa4sxm@amsat.org

to assist with the next project as well.

Lastly, please mark on your calendars the upcoming 2010 AMSAT Space Symposium the weekend of October 8-10 in Chicago. Details may be found on the AMSAT Web site.

Regards,
Barry Baines, WD4ASW
President

The AMSAT Store (see www.amsat.org) is back online! Here is a new AMSAT product. A handsome and functional AMSAT 10' locking carpenter's tape with both inch and metric scales.

Minimum donation: \$5



AMSAT[®] President's Club! Join Now!

Contribute to **AMSAT[®]** directly through easy, automatic charges to your credit card.
Donations may be USA tax deductible. (Check with your tax advisor.)

Titanium Donors contribute at least US \$400 per month.

Every **Titanium Donor** receives gifts of:

☐ \$400 / month

- ✓ Everything at the Platinum Donor Level, PLUS:
- ✓ A very special, *hand crafted*, AMSAT President's Club Donor's pin.

☐ \$4800 one time

Platinum Donors contribute at least US \$200 per month.

Every **Platinum Donor** receives gifts of:

☐ \$200 / month

- ✓ Everything at the Gold Donor Level, PLUS:
- ✓ A very special, *hand crafted*, AMSAT President's Club Donor's pin.

☐ \$2400 one time

Gold Donors contribute at least US \$100 per month.

Every **Gold Donor** receives gifts of:

☐ \$100 / month

- ✓ Everything at the Silver Donor Level, PLUS:
- ✓ A personal invitation to the AMSAT Dayton dinner (free).

☐ \$1200 one time

Silver Donors contribute at least US \$50 per month.

Every **Silver Donor** receives gifts of:

☐ \$50 / month

- ✓ Everything at the Bronze Donor Level, PLUS:
- ✓ A personal invitation to a reception with the AMSAT Directors, Officers and project designers and builders (free).
- ✓ Annual endorsement sticker after each year of donation.

☐ \$600 one time

Bronze Donors contribute at least US \$25 per month.

Every **Bronze Donor** receives gifts of:

☐ \$25 / month

- ✓ A unique "AMSAT President's Club" certificate.
- ✓ A specially designed AMSAT President's Club Donor pin.

☐ \$300 one time

Core Donors contribute at least US \$10 per month.

Every **Core Donor** receives gifts of:

☐ \$10 / month

- ✓ A specially designed AMSAT President's Club Donor pin.

☐ \$120 one time

Choose where your contribution should go:

☐ AO-Echo ☐ AO-Eagle ☐ ARISS ☐ Future Projects ☐ General Fund

☐ RENEW my
President's Club
AUTOMATICALLY
every year!

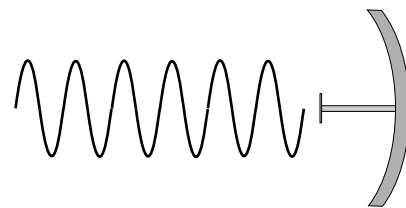
☐ I prefer to make my donation in one yearly payment of \$ _____.

(Credit card only, please.)

THANK YOU!



More AMSAT Photos from Dayton Hamvention



Always a hit at Hamvention, Keith Pugh, W5IU, keeps the crowd hopping with demonstrations of how easy it is to get on the satellites. If there is a satellite pass, Keith is outside making contacts to demonstrate satellite communications to other hams. Great job Keith! For more information on AMSAT at the Dayton Hamvention see Alan Biddle's article on page 11.



Barry Baines, WD4ASW, speaks during the AMSAT Forum.

Thank You! We've Met The Dayton \$5000 Challenge!

Thanks to the generosity expressed by AMSAT members and others, we have met the "Dayton Challenge" one-for-one matching gift goal of \$5,000.00. This goal was achieved in less than two months. AMSAT thanks the Dayton Amateur Radio Association (DARA) for their continued support of AMSAT. These donations will help support "Getting AMSAT Back into Space."

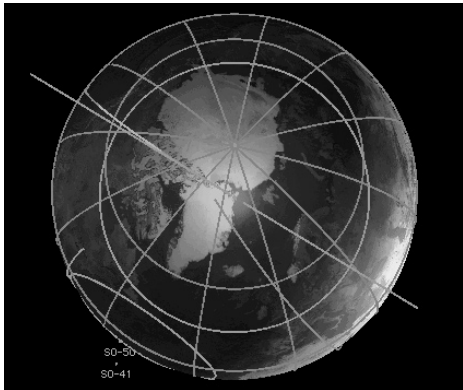
DARA President Steve Coy, K8UD, wrote to AMSAT President Barry Baines, WD4ASW, "I am glad that this promotion has worked well and I am looking forward to other endeavors in the future. AMSAT has been a major attraction to Hamvention for many years, and hopefully for many years to come. I hope other organizations will step up with similar programs. Launches have not been going down in price, however with the recent launch of Falcon 9, perhaps there may be other opportunities in the future. We all need to continuously look outside the box for new solutions. Again, DARA congratulates all the AMSAT members and best wishes for the new satellite."

While this one-for-one matching opportunity has been met, AMSAT continues on its capital drive to raise \$100,000.00 in both 2010 and 2011. One AMSAT member has just agreed to pledge \$500.00 to AMSAT as an additional 'one-for-one' matching opportunity, so donations made now will continue to "grow".

Since announcement of the campaign in October 2009, over \$25,087.00 has been raised to date, not including the DARA matching gift. If you haven't donated to AMSAT this year, please consider making a donation as we must continue to raise funds in 2010 to underwrite the construction and launch of our next satellite, Fox. We will continue to provide opportunities for 'small donations' at various hamfests as well as making contributions online via the AMSAT Web page. 🌐

MacDopplerPRO X

The premier Satellite tracking and station automation application for the Macintosh - OS 9 & OS X



MacDoppler for Cocoa gives you a seat right in the heart of the Operations & Command Centre for every satellite in orbit, providing any level of station automation you need from assisted Doppler Tuning and Antenna Pointing right on up to a fully automated Satellite Gateway !

It will calculate the position and relative velocity of the satellites you are tracking and automatically adjust the Doppler shift on both transmit and receive as well as pointing your antennas with predictive dead spot crossing so that a pass is never interrupted.

A Universal Binary that runs native on Intel and PPC Macs and provides separate panels for the map (2D or 3D), the radio and rotor controls, a sorted table of upcoming satellite passes and a Horizon panel that graphs upcoming passes as a function of elevation over time.

Now available from AMSAT at a special member discount donation!

martha@amsat.org
850 Sligo Ave.,
Silver Spring MD,
20910-4703 USA.
(301) 589-6062, (301) 608-3410 (Fax)

Dog Park Software Ltd.
www.dogparksoftware.com

Do you still use manual tuning to remove Doppler changes? Why not automate?

Uni-Trac 2000 will automatically tune your Receiver (and Transmitter) to compensate Doppler frequency changes. Uni-Trac will also STEER your Antenna !

Uni-Trac 2000, including Interface Cable \$280.00
FOB Concord, Mass. 01742, USA.



Spectrum International, Inc.,
P.O. Box 1084,
Concord, Mass. 01742, USA.
Tel: (978) 263-2145
Fax: (978) 263-7008

SSB ELECTRONIC USA

PHASE 3D Equipment Headquarters

SSB Electronic USA features world class VHF - UHF - SHF equipment. The latest gear from: SSB Electronic, Kuhne Electronic - DB6NT, M2 Antennas, Beko Electronic, EME, Procomm, AIRCOM PLUS, AIRLINK, ECOFLEX and WINRADIO is available.

- Mast Mounted Preamplifiers 144 - 2400 MHz.
- Ultra Low Noise LNA's 50.0 MHz. 24.0 GHz.
- Transverters 50 MHz. - 24.0 GHz.
- Antennas - Rotors
- Downconverters and TX Upconverters for all P3D frequencies
- Mode "S" Downconverters
- Mode "L" TX Upconverters
- Linear Amplifiers 50 MHz. - 24.0 GHz.
- Ultra Low Loss Coaxial Cable
- Transverter Kits 1.2, 2.4, 5.7 & 10 GHz.
- Parabolic Dishes

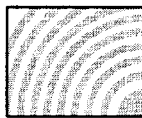
So What's New ?

BEKO Electronic: 144 MHz. - 1296 MHz. Linear Amplifiers 100 Watts - 1200 Watts

DB6NT Electronic: MKU 24 OSCAR Mode "S" Downconverter IF 144 or 432 MHz.
MKU 10 OSCAR 10.451 GHz. Down Converter
MKU 24 G2 OSCAR 2.4 GHz. Transverter 1 Watt
MKU 57 OTX 5.6 GHz. OSCAR TX Upconverter *plus more.....*

ECOFLEX - LLC Super Flexible Low Loss Coaxial Cable

SSB Electronic: UEK-3000SAT Mode "S" Downconverter IF 144 or 432 MHz.
UTM-1200 DLX Mast mounted 1269 MHz. 15 Watt TX Upconverter
UTM-1200-1 1269 MHz. 1 Watt TX Upconverter
SP-2000 & SP-7000 Heli-Filtered Mast-Mounted Preamps *plus more.....*



SSB
Electronic USA

For complete specifications and prices, please visit our WEB SITE: www.ssbusa.com

Phone 570-868-5643

New Hours: MTWTFSS
9:00 AM - 11:00 PM

124 Cherrywood Dr.
Mountaintop, PA 18707



HOPE-OSCAR 68: A New Hope in Space - XW-1

by Mike Rupprecht, DK3WN, dk3wn@amsat.org

Translation from German by Dr. Bernhard Michael Jatzek, VA6BMJ, from *The AMSAT-DL Journal*

Since December 2009 a new Amateur Radio satellite is in space. On board are a CW telemetry beacon, a linear transponder, an FM transponder and a store-and-forward packet radio mailbox. Since its launch, it's acquired the designation HOPE-OSCAR 68 (HO-68).

On December 15, 2009, at 0231 UTC, a Chang Zheng (Long March) 4C rocket was launched from the northern Chinese Taiyuan Satellite Launch Center (Shanxi Province, Figure 1) to deliver the main payload, the earth observation satellite Yaogen-8, into space. Originally, the CZ-4C is configured to transport only one satellite into space. Within a short time, the rocket for this particular mission was modified and tested for facilitating the subsequent delivery of two satellites. The secondary payload

was the first Chinese Amateur Radio and experimental satellite Xi Wang 1 (Xi Wang means hope, Figure 2).

The launch took place a few days before the more or less official launch day and I was quite surprised, as on the morning of December 15, I received a message from

At 22 minutes after the launch, at 0243 UTC, XW-1 was successfully placed in its orbit at 1200 km altitude. Immediately afterwards, BA7JA, BA7NQ, and BA7IA reported receiving the beacon in Sanya (Hainan Province). In Europe, we had to wait until the morning hours, after which

the first successful reports came from here as well. A strong and, on the whole, stable CW signal announced the good condition of XW-1.

XW-1 was built mainly to provide younger people with an insight and first experience with spaceflight and space technology.

- Organization: China Association for Science (Chinese Society of Astronautics) with support from the National Space agency and China Aerospace Science

and Technology Corporation



Figure 1: Launch of HOPE-OSCAR 68 from the northern Chinese Taiyuan Satellite Launch Center.

Alan Kung, BA1DU, (Figure 3) that XW-1 was in space and that the first signals were received.

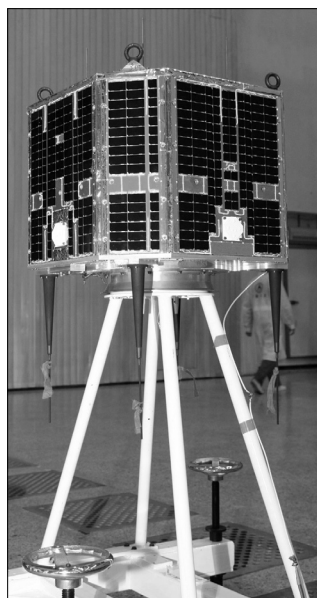


Figure 2: The Amateur Radio satellite XW-1 (HOPE-OSCAR 68).

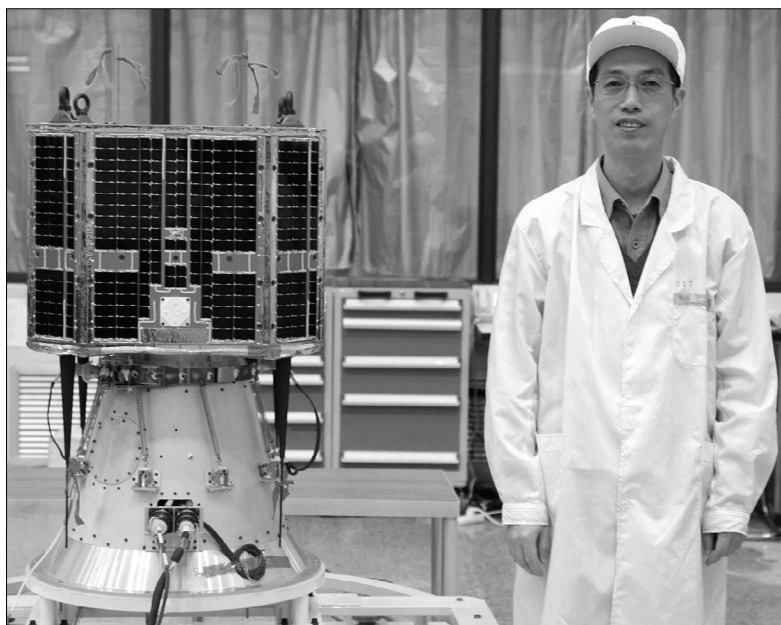


Figure 3: XW-1 and project leader Alan Kung, BA1DU.

- Sponsors: Chinese Society of Astronautics, China Association for Science Technology Center for Youth
- Co-organizations: China Carrier Rocket Technology Research Institute, Chinese Academy of Space Technology, Shanghai Academy of Space Technology, Aerospace Dongfanghong Satellite Co., Ltd., Chinese Radio Sports Association

Mission Objectives

A physical experiment based on an idea from schoolchildren and concerned with the motion of particles in space under nearly weightless conditions. For that, the motion of five different types of existing particles is observed in orbit.

Taking panoramic pictures of the earth is a further mission objective. For that, a wide-angle CMOS color camera with a resolution of 1.4 km/pixel is used.

The Amateur Radio payload of XW-1 consists of a CW telemetry beacon, a linear transponder, an FM transponder, and a store-and-forward packet radio mailbox (Figures 4 and 5). Six days after its successful launch, XW-1 was given the designation HOPE-OSCAR 68.

Technical Data

Antennas:

145 MHz RX antenna: -2.0 dBi, LHCP
435 MHz TX antenna: -3.0 dBi, RHCP

XW-1 Platform Specifications

Structure:

Unequal lateral prism, frame and basic sides from aluminum alloy

Mass:

60 kg

Measurements:

680 mm x 480 mm (without antennas), 680 mm x 974 mm (with antennas)

Thermal model:

Passive

Interior temperature: -20° C - +45° C

Power supply:

Triple-junction GaAs solar cells, 17 A-h lithium-ion battery

Primary voltage: 28 V

Secondary voltage: 5 V and 12 V

Average output: 13 W

Peak output: 31 W

The structure is divided into three sections: power supply, electronics and payload.

Orbital parameters:

Altitude: 1200 km

Inclination: 105°

Period: 109 min.

Amateur Radio Payload

CW Beacon

Downlink: 435.790 MHz CW

The beacon is permanently operating and transmits with an output of about 200 mW. In 40 seconds, a complete telemetric data set is sent at about 15 wpm, followed by a 10 second pause. The transmission follows in abbreviated CW notation, which we know from LO-19 or SwissCube (for example, t = 0, a = 1, u = 2, etc.). The telemetric information (status, temperature and voltages) is transmitted in 13 channels (Figure 6). Software for decoding the data (Figure 7) is available on my Web site for downloading at: www.dk3wn.info

Example:

BJ1SA XW XW TTT TAT AUE TTT ETT
U4D TT4 BET EBT TTT TTT UNU ETT
XW XW

PA Output RF Switch Status: PA1 works (transponder and beacon)

Transponder Working Status: Beacon and FM transponder

Transponder Temperature: 25° C

Beacon RF Output Power: 0 mW

Beacon Power Supply Volts: 5 V

Receiver Power Supply Curr: 248 mA

Linear Transponder ACG Volts: 0.04 V

Transponder RF Output Power: 2250 mW

Transponder PA Curr: 570 mA

Linear Transponder Up Conv: 0 mA

Linear Transponder Volts: 0 V

FM Dig S/F Transponder Curr: 292 mA

FM Dig S/F Transponder Volts: 5 V

FM Transponder

Uplink: 145.825 MHz FM, PL 67.0 Hz

Downlink: 435.675 MHz FM

XW-1 flies, with its 1200 km orbit, higher than other FM satellites. Accordingly, it has a substantially larger footprint. During a single favorable pass, all of Europe, north Africa, Russia and parts of west Asia are covered. An unbelievable number of stations with different transmission output powers, perspectives and operating techniques meet together on a single FM channel. Will it generally work out? Whenever a new FM mode satellite is available, the discussion on how to efficiently use it for QSOs begins again. Experiences in Europe always show chaotic circumstances (e. g., AO-27). When only one channel is available, a good operating technique and discipline are indispensable. At this point, once again, a few basic thoughts about operating techniques:

- The first and golden rule -- first listen, then send!
- Don't call during on-going QSOs or call CQ -- wait, even when it's hard to resist.
- Whistling, tapping, "hello, hello", and so on is superfluous -- on an FM transponder, extra sounds are unnecessary.

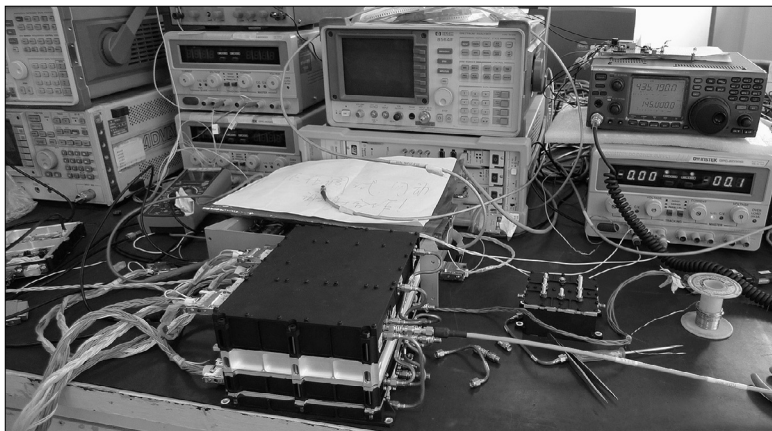


Figure 4: Development and test of payload.

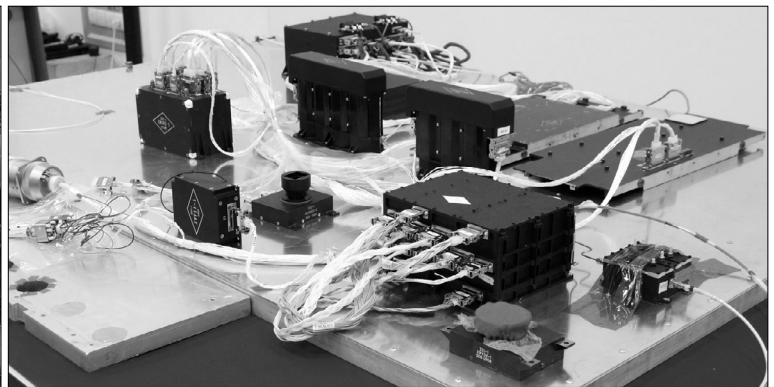


Figure 5: Interior layout with the XW-1 experiments.

continued on page 29 ...

2009 Space Symposium and AMSAT-NA Annual Meeting

Held October 9, 10, 11, 2009 at the Baltimore, MD, Airport

Contents include articles on ARISSat-1, Amateur Radio on the ISS, new satellite projects and more. For example:

- The ARISSat-1 Linear U/V Transponder
by Bill Ress, N6GHZ
- Amateur Radio on the ISS
by Keith Pugh, W5IU
- Hall Effect Thrusters for AMSAT Satellite Missions
by Daniel Schultz, N8FGV
- AO-7's Solar Power Array Power After 35 years in Orbit
by James A. DeYoung, N8OQ
- Software Radio Technology on ARISSat-1
by Anthony Monteiro, AA2TX
- AMSAT NextGen Satellite Project
by the NextGen Satellite Team and Alex Harvilchuck
- AMSAT Eagle - Building a Mission for Education
by JoAnne Maenpaa, K9JKM
- Using a Software Defined Radio with Integrated VHF/UHF for Satellite Operations
by Stephen Hicks, N5AC, Greg Jurrens, WD0ACD, and Ken Simmons K5UHF

To Order:

Proceedings - 2009

(8½" x 11", 180 pages)

Minimum donation:

\$20 in the U.S. + postage.

For rate to your mailing address see: www.amsat.org and click on "AMSAT Store". VISA, MasterCard or Discover charges accepted.

Write, telephone or FAX:

AMSAT-NA

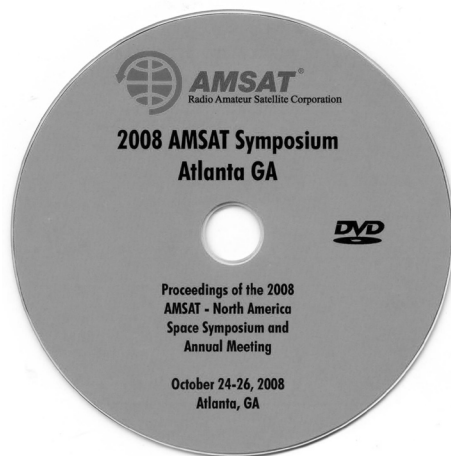
850 Sligo Ave. #600

Silver Spring, MD 20910, USA

Tel: 301-589-6062

Fax: 301-608-3410

Now Available!



2008 Proceedings DVD's also available. Contact the AMSAT Office.

A new DVD for the 2008 Symposium is available.

It has the presentations, audio files and papers.

Dan Schultz's Banquet Talk on The Hubble Space Telescope Repair Mission - slides and audio

Phil Hartman's Introduction to DSP Workshop - slides and audio plus

2004 Symposium papers

2005 Symposium papers

2007 Symposium papers

BJ1SA	XW	XW	CH	CH	CH	CH	CH	CH	CH	CH	CH	CH	CH	CH	CH	XW	XW
			1	2	3	4	5	6	7	8	9	10	12	12	13		

Figure 6: The telemetric data (status, temperature and voltages) are transmitted in 13 channels.

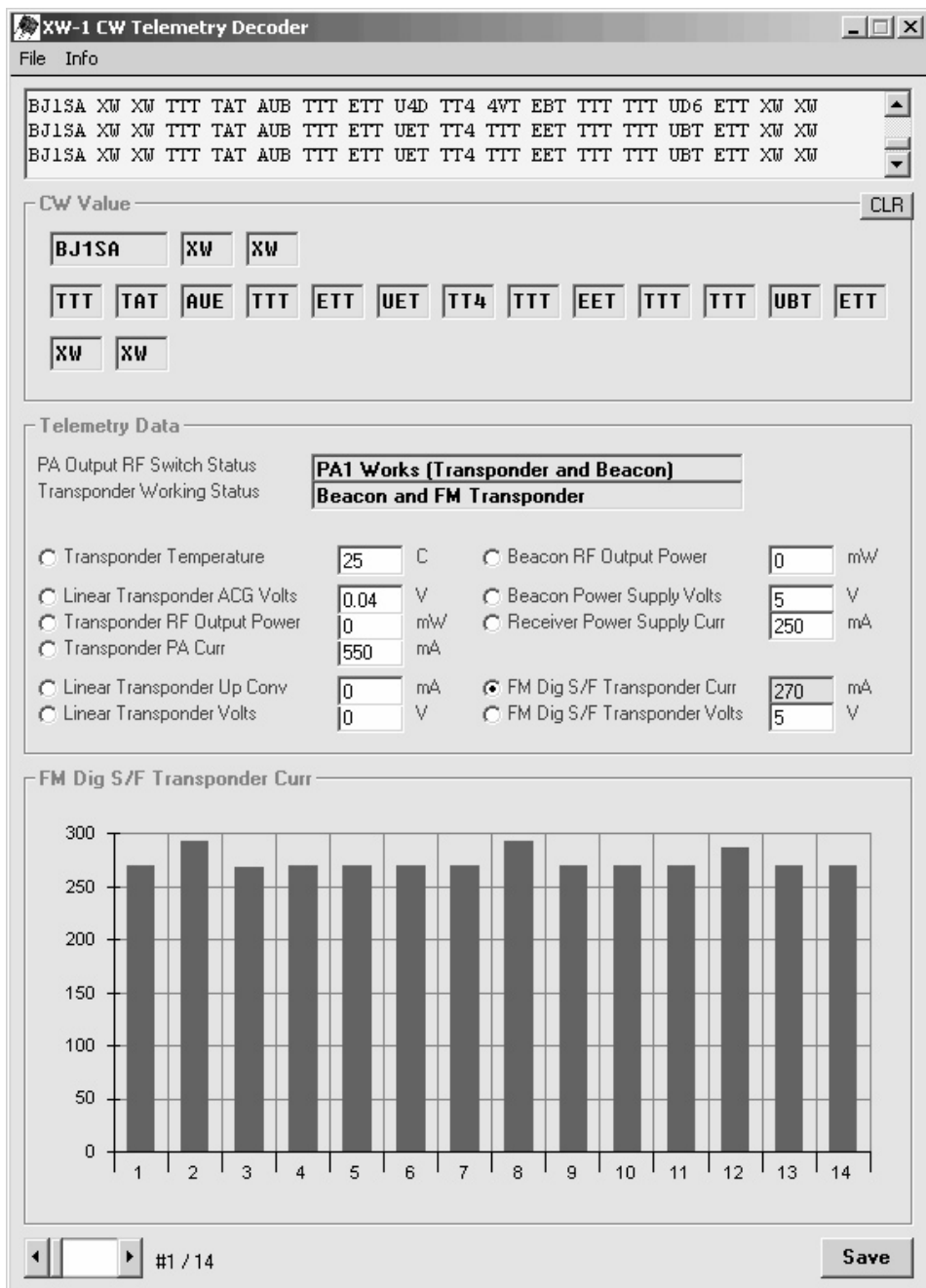


Figure 7: Software for decoding the XW-1 telemetric data.

FileNum	S To	From	Upload Time	F Size	% Title	Keywords
E3	P BA1DU	ST2NH	1933 18Jan10	376	tnx new schedule	<W> w
E2	P WAASCA	ST2NH	1933 18Jan10	369	hello	<W> w
D8	N NBH	DK3VN	1142 09Jan10	429	hello	
D7	g ST2NH	DD1JSN	1141 09Jan10	397	Happy New Year	HNW
D6	g W8SL	DD1JSN	1141 09Jan10	394	Happy New Year	HNW
D3	g JE9PEL	ST2NH	1853 08Jan10	440	tnx	<W> w
D2	g W8SL	ST2NH	1852 08Jan10	423	hello on	<W> w
D1	g BA1DU	ST2NH	1852 08Jan10	419	tnx new schedule	<W> w
D0	A ALL	ST2NH	1852 08Jan10	398	hello	<W> w
CF	g HB9SKA	ST2NH	1851 08Jan10	391	hi thomas	<W> w
CE	E DK3VN	ST2NH	1851 08Jan10	366	photo msg	<W> w
CD	E DK3VN	ST2NH	1851 08Jan10	298	hello	<W> w
C5	g BA1DU	ST2NH	1844 02Jan10	434	tnx hope 1	<W> w
C4	E JE9PEL	ST2NH	1843 02Jan10	419	hny	<W> w
C3	D DK3VN	ST2NH	1841 02Jan10	395MSG	HNW	<W> w

Figure 8: The XW-1 packet radio mailbox.

- Reduce output to a minimum -- an overloaded transponder helps no one
- Keep the QSOs short and essential. Here there is a difference of opinion. Is it necessary to send the grid square? During an HF contest, such a report would be a valid QSO. In Europe, we've developed this style, but isn't it more effective to work in contest mode? When the satellite was quite busy, callsign and signal report -- that was it. Name, QTH or even the station equipment can be exchanged when one is truly alone on the transponder.
- Practice discipline, limiting yourself to one QSO each pass. During those precious minutes, everybody has a turn. I often sat there with my microphone in my hand and never had a single QSO.
- There will always be stations which will be annoying (due to their operating style). It is, however, senseless to interfere with these stations. It doesn't help anyone else.
- We respect QSOs in different languages. It actually works with suitable discipline and short QSOs. A pass is often multilingual and listening in can be lots of fun.

Perhaps we shouldn't get caught up with the daily chaos and try through our own operating techniques to show a bit more discipline. It's difficult, but we should try it, even when the finger on the microphone key is itching, the output regulator isn't doing anything and when one's eyes are rolling when the name or location is repeated for the third time.

Maybe we can succeed, then, if we use the existing FM satellites that way, just like it's been long been successfully done over existing SSB transponders. With XW-1, we have the chance to work other continents in FM.

Digital-Store-and-Forward-Transponder (BBS)

Uplink: 145.825 MHz FM 1k2 AFSK AX.25

Downlink: 435.675 MHz FM 1k2 AFSK AX.25

After the loss of GO-32, a packet mailbox is finally in space once again! However, after a few days, it showed certain limitations. The packet BBS shares its 16 kHz wide FM channel with the voice transponder. The 67 Hz PL tone sets the switches. It isn't a good solution, two different operating modes using the same frequency with the AFSK





Figure 9: First SSTV attempts over the XW-1 linear transponder.

signals interfering with each FM QSO and vice-versa. Therefore, in Europe or North America, it's difficult to get access to the BBS. During a typically busy session on the transponders, one can, with only lots of luck, send a short message or access the mailbox directory.

I spoke with Alan Kung about this problem and he confirmed to me the possibility of modifying the satellite's software. That will, however, be a project for the future.

For working with the XW-1 mailbox, one uses the popular PACSAT management software WISP32 (Figure 8).

Broadcast call: BJ1SA-11

BBS call: BJ1SA-12

Linear Transponder

Uplink: 145.925 - 145.975 MHz LSB/CW

Downlink: 435.765 - 435.715 MHz USB/CW

On December 23, 2009, the first activation of the linear transponder over Europe took place. The 50 kHz frequency range was well-occupied and many of us made our first XW-1 QSOs that evening and were surprised at the good signals. During the next days, the first transcontinental QSOs took place. It was quite possible for us to work four continents during a pass.

Several days later, on December 30, 2009,

during a low-elevation pass, Henk, PA3GUO, and I made the first experiments with SSTV over the XW-1 linear transponder (Figure 9).

These positive results leave room for additional interesting experiments, as well as other digital modes (e. g., HELL, PSK31) that have already been successfully tested over other linear transponders (FO-29 or VO-52). Meanwhile, XW-1 is switched on

several times daily, with the FM and linear transponder operations being alternated every few days. The actual transponder operating schedule can be found on CAMSAT's Web site at www.camsat.cn.

With HOPE-1 a new Amateur Radio satellite with many possibilities for our experimental hobby was made available for our use. My personal hope is to use it efficiently and sensibly for a long time. 🌐



Figure 10: The antenna array at the launch center.

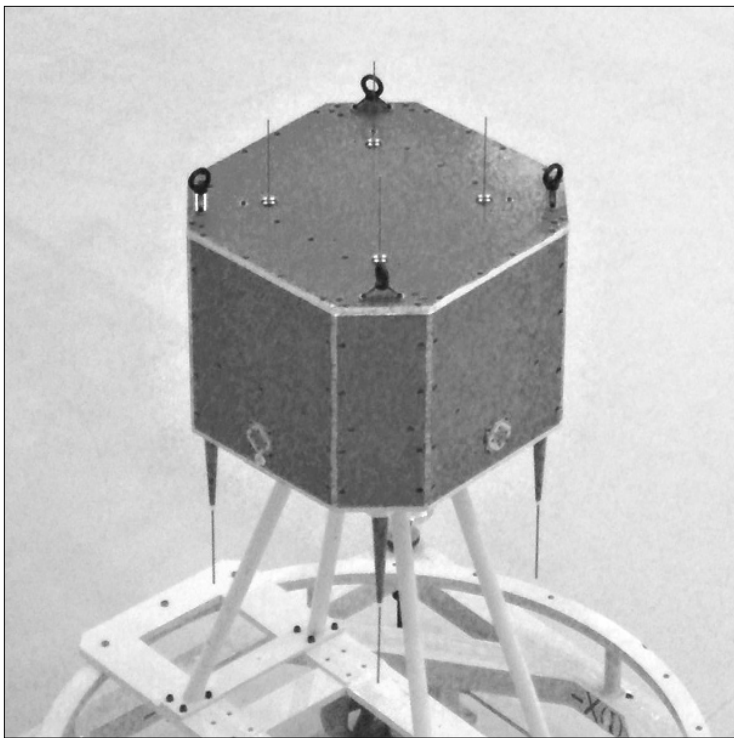


Figure 11: The XW-1 flight configuration.

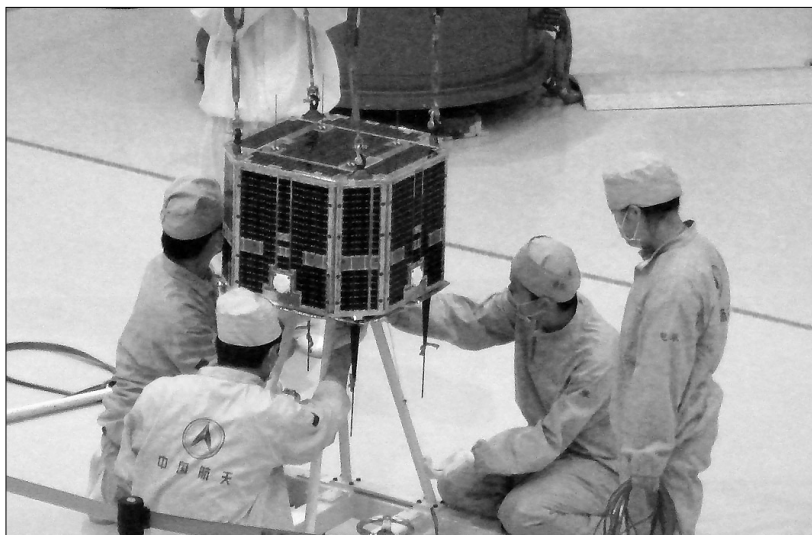


Figure 12: The XW-1 in mechanical test.

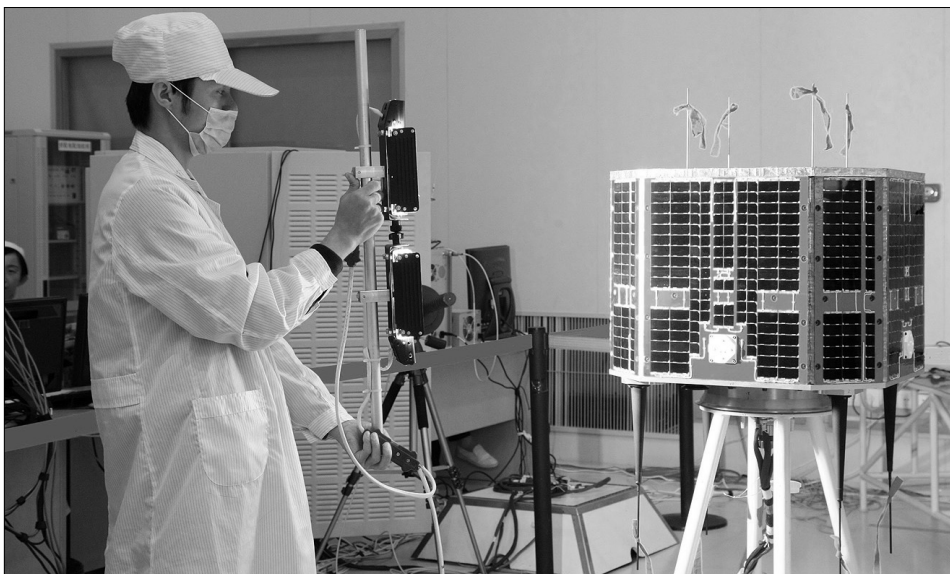


Figure 13 (left): The XW-1 in illumination test.

Reach for the stars.

N3UC, formerly N4USI, control operator of AO-27, says, "AO-27 may be getting old and failing at times, after 15 years circling the earth. But, my IC-910H that I use to control AO-27, using data transmissions, has never failed me".

Icom 910H The perfect satellite rig.



Have fun communicating with these satellites using the IC-910H:

AO-27, SO-50, AO-51, and VO-52.

In the near future, check out these satellites:

AMSAT-Phase 3E, AMSAT-Eagle, SumbandilaSAT, and KiwiSAT.

Coming to the sky near you! Visit an authorized Icom dealer today!

amateur | avionic | land mobile | marine | receiver | system | www.icomamerica.com

*For further satellite information visit www.amsat.org.

©2009 Icom America Inc. The Icom logo is a registered trademark of Icom Inc. AMSAT is a registered trademark of the Radio Amateur Satellite Corporation. 30122

ICOM®